

Comdr. W. R. Wilsony and
J. S. S. T. E. Fraser DM 24
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June 1919

MINES, MINELAYERS AND
MINELAYING

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AND
MINELAYING

BY

CAPTAIN J. S. COWIE, C.B.E.

Royal Navy

Geoffrey Cumberlege

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To
Past and Present Members
of the
Minelaying Team

‘These outstanding successes continue to be made possible by the sustained efforts of the crews who lay the mines and of the personnel who design, manufacture, assemble, and supply them.’ *Extract from joint Admiralty and Air Ministry Communique, 28 June 1943*

Any opinions expressed in this book are solely those
of the Author

FOREWORD

By ADMIRAL SIR ROBERT BURNETT, K.C.B., K.B.E., D.S.O.

(Rear-Admiral, Minelayers, from November 1940 to February 1942)

I HAVE agreed to accept the compliment paid me by the author in asking me to write a short Foreword to this educative, and not only educative but most interesting and valuable book.

I am not a technical expert on the mine, but acted for nearly two years at the delivery end of the pipe line which had its source in the brains, energy and enthusiasm of Captain De Salis and the author.

It was a privilege to work in the same team as these enthusiasts, where I learned a considerable amount of the intricate mechanism and inherent temperamentality of an infinite variety of this most unpleasant of all weapons. The author, on the other hand, is a great expert who has devoted the last quarter of a century to under-water weapons, both from a technical and operational standpoint. Australian born, he experienced good fighting service in the War of 1914-18 at Jutland, Zeebrugge and Ostende, and passed his sub-lieutenant's courses with a galaxy of 'firsts.' When in 1923 he qualified as a torpedo officer, he gained the Ogilvy Gold Medal as the 'best of the year' in this intricate subject.

The hard study necessary to achieve these distinctions might well have turned him into a complete mechanical 'X-chaser', but he was in his youth a really fine athlete and an excellent exponent of the game of Rugby football. These qualities, when allied to a love of the stage and very considerable ability as a producer and author, assisted him in maintaining his sense of proportion and very considerable sense of humour. Both are quite essential in the minelaying business, because there is nothing inherently amusing in steaming in foul weather, attacked at times by aircraft and submarines, with some 560 primed mines on board, and laying them with great accuracy in the close proximity of previous fields which may or may not have drifted. It was well, therefore, that those

at the planning end of the line felt the point of view of the operators.

Captain Cowie has written a book largely on technical matters which is of the greatest interest even to one who has never wanted to look into a watch or a motor car to see how the works go round. It is a book which must be of value to the student of strategy, for the mine is a potent strategic weapon; and thus it is a book which is of value to all naval officers who aim to command His Majesty's ships at sea. Further, it is a book of value to the student of under-water warfare, for (and here I take leave to differ from Commander J. A. Fisher—Lord Fisher of Kilverstone could never have written the words he wrote as a young officer in his handbook) it is only by paying close attention both to the failures and successes of our predecessors that we can correct their mistakes and further develop the work they have left to us to perfect.

ADMIRALTY HOUSE

DEVONPORT

November, 1948

PREFACE

THE mine has played a progressively important part in the conduct of war since the first crude examples were made some 350 years ago.

Minelaying can never be an end in itself, but must always be an adjunct to the operations of other forces. The successful management of mining material calls for a different technique to that required for the employment of the weapons normally carried by ships and aircraft, while an extensive minelaying campaign in enemy waters can have an effect which reaches far beyond the limits of maritime operations as such.

The first official handbook on this subject was written by Commander J. A. Fisher, R.N., later to become Admiral of the Fleet Lord Fisher of Kilverstone. In a characteristically dynamic foreword, the author insisted that students of the subject should concentrate on the material then in existence or under development, on the grounds that no value was to be derived from a study of the ingenious but futile efforts of their ancestors.

With great respect, I take leave to dissent from this view. Not so much because all history has taught us the value of an intelligent study of the past, but rather because every work of man is inevitably destined to become the effort of somebody's ancestor, and I am not competent to judge of the precise moment at which futility sets in, if indeed it ever does.

I have therefore seen fit to trace the development of mine warfare since its earliest days, my object being to dispose of certain popular misconceptions about the mine, to examine its influence in the strategic, economic, and political spheres, and to present a picture of the technical and industrial factors involved.

I hope in addition to have recorded some thoughts which may be of help to those charged with the development of our mining material and with the study of its employment in war. I hope with equal sincerity that they may never be called upon to apply the fruits of their labours. But to be effective in its traditional role as an instrument of peace the Royal Navy

must be properly equipped in all arms, and the taxpayer must be in a position to judge the usefulness of any particular type of weapon for which he may be asked to provide the money.

It is for these reasons that the later chapters are primarily devoted to a consideration of British mining material and effort.

At the end of this book is a list of publications to which reference has been made in collecting material. In dealing with the early developments, valuable assistance has been derived from *The Evolution of the Submarine Boat, Mine, and Torpedo* (1907), and I am grateful to the author, Admiral Sir Murray Sueter, for his personal encouragement. *The Hague Peace Conference* (1909), by the late Professor Pearce Higgins, has been consulted in relation to the attitude of the Powers concerned in drawing up the Eighth Convention on Minelaying. Much of the sections covering the technical aspect of the magnetic mine campaign has been based on a lecture delivered to the Royal Society of Arts in December 1945 by Sir Charles Goodeve, on papers read before the Institution of Electrical Engineers in April 1946 by H. W. K. Kelly, M.A., and D. H. Parnum, B.Sc., Ph.D., and on a contribution to *Discovery* for January 1946 by Lieut.-Commander S. J. Brookfield.

My thanks are also due to Dr. E. C. Wadlow for his advice in the preparation of many of the illustrations, and to Mr. D. Bonner-Smith and the staff of the Admiralty Library for their unfailing help.

Finally, I must record my indebtedness to Captain R. H. De Salis, O.B.E., D.S.C., R.N., who first inspired my interest in the subject and subsequently taught me all I know of the management of minelaying resources.

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November, 1948

CONTENTS

FOREWORD	vii
PREFACE	ix
ILLUSTRATIONS IN TEXT	xii
PLATES	xiv
MAPS	xiv
I. INTRODUCTORY	I
II. EARLY DEVELOPMENTS (from 1585 to 1865)	7
III. FURTHER DEVELOPMENTS (from 1865 to 1914)	24
IV. WORLD WAR I—FIRST PHASE (from the outbreak of war to December 1916)	43
V. WORLD WAR I—SECOND PHASE (from January 1917 to the end of the War)	58
VI. BETWEEN THE WARS (from 1919 to 1939)	88
VII. WORLD WAR II (The Campaign in British Waters)	119
VIII. WORLD WAR II (The Campaign in Enemy Waters)	139
IX. THE MINE IN INTERNATIONAL LAW	168
X. RETROSPECT AND PROSPECT	181
APPENDIX	
I. THE MATHEMATICAL CHANCES OF A SHIP STRIKING A MINE	200
II. PRINCIPAL BRITISH MINELAYERS—WORLD WAR I	203
III. PRINCIPAL BRITISH MINELAYERS—WORLD WAR II	205
REFERENCES	207
INDEX	209

ILLUSTRATIONS IN TEXT

FIGURE	PAGE
1. THE FIRST MOORED MINE	15
2. SINGER'S MINE	19
3. BROOKS' MINE	20
4. THE 'DAVIDS' WITH SPAR TORPEDOES	22
5. AN OBSERVATION MINEFIELD	25
6. AN ELECTRO-CONTACT MINEFIELD	26
7. THE HERZ HORN	26
8. THE PLUMMET SYSTEM OF AUTOMATIC DEPTH-TAKING (NON-BUOYANT)	29
9. THE HYDROSTATIC SYSTEM OF AUTOMATIC DEPTH- TAKING	30
10. JAPANESE MINE	32
11. RUSSIAN MINE	33
12. THE BRITISH NAVAL SPHERICAL MINE	35
13. THE CARBONIT MINE	37
14. THE LEON MINE	37
15. THE FRENCH SAUTER-HARLÉ MINE	39
16. THE FRENCH BREGUET MINE	39
17. THE 'SPROCKET WHEEL' SWEEP EVADER	45
18. THE BRITISH 'ELIA' MINE	47
19. DRIFTING, OSCILLATING, AND CREEPING MINES	50
20. THE ELECTRO-CONTACT MINED NET	55
21. THE PROTECTOR PARAVANE	57
22. THE NORTHERN BARRAGE, 1918	63
23. THE ANTENNA MINE	66
24. THE FOLKESTONE-GRIS NEZ BARRAGE, 1918	73
25. THE 'E.C.' ATTACHMENT	76
26. THE 'S.M.' SCHEME	77

FIGURE	PAGE
27. THE 'OROPESA' SWEEP	85
28. THE HIGH SPEED MINESWEEP	85
29. THE BRITISH H.II MINE	89
30. THE PLUMMET SYSTEM OF AUTOMATIC DEPTH-TAKING (BUOYANT COMBINATION)	89
31. EFFECT OF 'DIP' AND RISE AND FALL OF TIDE	90
32. THE BRITISH MARK XIV MINE	91
33. THE 'LOOSE BIGHT' SYSTEM OF HYDROSTATIC DEPTH- TAKING	94
34. HYDROSTATIC DEPTH-TAKING. EFFECT OF CURRENT	94
35. A SHIP IN THE EARTH'S MAGNETIC FIELD	99
36. A SHIP IN THE VERTICAL COMPONENT OF THE EARTH'S FIELD	99
37. BRITISH MAGNETIC GROUND MINE	101
38. A 'LOOP' CONTROLLED MINEFIELD	103
39. 'WIRE AND BOGIE' METHOD OF LAYING MINES.	110
40. 'CHAIN CONVEYOR' METHOD OF LAYING MINES	111
41. THE 'LL' MAGNETIC SWEEP	129
42. H.M.S. <i>MANXMAN</i> DISGUISED AS A FRENCH CRUISER.	149
43. THE PRESSURE, OR 'OYSTER' MINE	163

PLATES

I.	(a) H.M.S. <i>LATONA</i>	<i>facing p.</i>	51
	(b) H.M.S. <i>PRINCESS MARGARET</i>		
	(c) H.M.S. <i>ABDIEL</i> (1916)		
II.	COASTAL MOTOR BOAT MINELAYER	,,	82
III.	(a) H.M.S. <i>ADVENTURE</i>	,,	83
	(b) H.M.S. <i>RORQUAL</i>		
	(c) H.M.S. <i>ABDIEL</i> (1940)		
IV.	(a) H.M.S. <i>PLOVER</i>	,,	98
	(b) H.M.S. <i>PRINCESS VICTORIA</i>		
	(c) H.M.S. <i>SOUTHERN PRINCE</i>		
V.	(a) MINELAYING AIRCRAFT AND MAGNETIC MINE	,,	99
	(b) MINELAYING MOTOR LAUNCHES		
VI.	THE TRANSPORT PROBLEM	,,	157

MAPS

(*at end of book*)

BRITISH AND AMERICAN MINEFIELDS, 1914-18

BRITISH MINEFIELDS IN THE FAR EAST, 1939-45

BRITISH MINEFIELDS IN EUROPE, 1939-45

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CHAPTER I

INTRODUCTORY

IN the normal course of human conflict we tend to confine ourselves to the idea of mobile weapons. Such things as shells, torpedoes, depth-charges, and bombs are all *missiles* aimed at a specific target. They all achieve their object—or fail to do so—very shortly after they are released from human control, and their proper use is a matter for the captain of the ship or aircraft in which they are carried. He in turn is assisted by officers and men trained in the management of various devices whose design is directly related to the tactical purpose in view.

It is perfectly true that certain specialized types of mine have on occasion been directed to the destruction of pre-selected targets, and equally true that in certain circumstances 'tactical' minefields have been laid directly in the path of an enemy ship or group of ships. It is only in these exceptional circumstances that the officers and men of a minelayer can influence the immediate result. In the great majority of cases the long-term static minefield, laid in accordance with a pre-conceived plan, must be regarded as the weapon, and one moreover *to which the enemy must come* if he is to be sunk or damaged. It is thus only in the accurate placing of the mines in positions selected by higher authority that those who actually lay them can normally contribute to the success of a minelaying campaign, a statement which in no sort of way indicates a failure to appreciate the skill, courage, and determination of the officers and men concerned.

In peace, mines can be developed from the purely technical point of view, and minelaying can be exercised in the parochial sense of tipping the mines into the sea from a ship or dropping them from an aircraft. Mine *warfare*, on the other hand, can only be studied. It cannot be practised in the full sense of the term, as it is impossible for the economic, strategic, or political effects to be simulated. There is in consequence a tendency in peace exercises for mines to be laid by the simple expedient of drawing red areas on the charts.

From the point of view of those who hold the national purse-strings, there is in peacetime a natural reluctance to provide ships and weapons which do not give an immediate and tangible return for the money expended, while finally there is the school of thought founded in 1804 by Earl St. Vincent when he declared that 'Pitt was the greatest fool that ever existed to encourage a mode of warfare which those who commanded the seas did not want, and which if successful would deprive them of it'. This theory informed the British outlook on mine warfare for a great many years and had a deleterious effect on our preparedness for war comparable with the widely held view that the mine was an ungentlemanly contrivance.

The sum of all these considerations was a tendency in peacetime for the mine to recede further into the background of naval thought and planning. This tendency was to some extent checked in the years immediately preceding World War II, and in 1939 Great Britain undoubtedly found herself far better equipped in this respect than she was in 1914. There is good reason to believe that the lessons of both wars have been assimilated, but we should do well to note the comments made by a senior German mining expert in 1945 to the effect that 'no weapon falls more rapidly into disrepute if improperly handled'. In other words, if in peacetime we forget the operational principles involved, technical excellence in war will avail us nothing.

In war, a minefield may not achieve any concrete results until some time after it has been laid, and in all probability there will be a further time-lag before reliable intelligence of these results is received and digested. On the other hand, a minefield may achieve its object without sinking any ships at all. The planner thus works in a sort of mental vacuum, and he must acquire the ability to judge the general *trend* of events and to resist the temptation to alter his plans in the light of short-term changes in the situation. He must also be on the alert to counter any suggestion that a minefield can in itself present an impenetrable barrier to a determined enemy. He must in addition have constantly before him the fact that the mine cannot distinguish between friend and enemy, and

that every minelaying plan must therefore take into account the safety and freedom of movement of his own and allied forces and the requirements of future naval operations.

Finally, to enable him to discharge his functions efficiently, the planner must not only be kept in the strategic and political picture, but he must have access to the most up-to-date and accurate intelligence of the enemy.

It has been pointed out above that technical excellence may well be defeated by inept handling. It is equally true that those in charge of a minelaying campaign must have a thorough grasp of the technical capabilities and limitations of their material. Having outlined in broad terms the operational peculiarities of the mine, it would therefore be well to round off these introductory remarks with some technical definitions. The mine, as we shall see, has been developed from a crude arrangement of gunpowder, fired by a flintlock, to a charge of high explosive detonated by the operation of a complex mechanism, and it is clear that however general the terms in which these definitions are framed, some of them must apply to the present rather than to the past. It is, however, thought best to see the whole extent of the canvas before attempting to paint the picture.

Broad Definitions

All mines fall into one of two main categories: independent and controlled.

Independent mines are those used for all purposes other than the close defence of harbours. Once laid, they normally remain dangerous to friend, enemy, and neutral until they are swept up or become ineffective due to natural deterioration, but in certain cases the effective lives of independent mines are artificially restricted.

For many years the term 'non-controlled' was applied to this type of mine, being discarded in favour of the equally descriptive but less cumbersome modern title.

Independent mines are further defined according to the position they occupy in relation to the bottom of the sea:

Moored (or Buoyant) Mines

The popular conception of the mine, and the type most widely used up to the end of World War II, being anchored below the surface of the sea by means of a 'sinker' and a wire mooring rope. As a general rule, the sinker also acts as a trolley on which the mine is mounted for laying from the rails of a minelayer.

Ground Mines

These rest on the sea-bed, and are in effect combined mines and sinkers.

Drifting, Creeping, and Oscillating Mines

Drifting mines are free to move under the influence of tide and wind. They either remain floating on the surface of the sea, or (more generally) are suspended below the surface from a small baulk of timber or other innocent-looking object.

Creeping mines are a specialized form of drifting mine, kept below the surface by means of a length of chain which drags along the sea-bed.

Oscillating mines are more elaborate in design, a source of energy such as compressed air or gas being utilized to maintain them somewhere near a pre-selected depth below the surface of the sea.

Finally, independent mines are classified according to the method of actuation:

Contact Mines

These fire if a ship hits them.

Non-Contact, or 'Influence' Mines

These fire on the near approach of a ship due to some property of the ship herself, e.g. magnetic, acoustic, etc. The term 'influence', introduced during World War II, is now in more or less common use.

Moored, drifting, creeping, and oscillating mines may be of the contact or the influence type, but ground mines can for obvious reasons be of the influence type only.

Controlled mines, as their name implies, are always under human control, being either rendered safe or dangerous at

will, or else capable of being fired from the shore. Used primarily for harbour-defence purposes, they involve the setting up of a shore-observation station and the laying of electric cables between that station and the minefield.

Controlled mines may be of the ground or moored type, but in the latter case they are always laid at a depth greater than the draught of the heaviest friendly ships likely to use the channel of whose defences they may form a part.

For subsequent ease of reference, the various classifications are set out below in tabular form:

<i>Independent</i>			<i>Controlled</i>
<i>Moored</i>	<i>Drifting, Creeping, Oscillating</i>	<i>Ground</i>	<i>Moored or Ground</i>
Contact or Influence	Generally Contact but may be Influence	Influence only	<i>Either</i> Fired from the shore <i>or</i> Put to 'Safe' or 'Dangerous' from the shore.
Incapable of distinguishing between friend and enemy, but effective lives may be artificially restricted.			

The clarity of the foregoing statement is to some extent marred by the fact that there are one or two types of mine which do not fit completely into this picture.

For example, there is the type which is actually fastened by some means to the hull of an enemy ship while she is at anchor, or placed beneath her hull in shallow water, and fired by means of a time fuse. The earliest underwater weapons, to be described in the next chapter, were used in this way, and the idea was revived in World War II in the Limpet. These weapons are of some interest in tracing the cycle of development, but in the opinion of traditionalists they should be regarded as torpedoes rather than mines, being directed at a specific

target and entirely dependent for their success on the skill of those who actually place them.

The second awkward child is the Antenna mine. This weapon will be described in its proper turn, and it is perhaps sufficient here to discount the popular theory that it is fitted with long feelers like a beetle. The Antenna mine, in fact, is simply an independent moored contact mine actuated in a novel way.

This completes the technical picture in its simplest form. There are, naturally, various possible combinations and permutations of the different types, but with these introductory remarks as a background it is hoped that the reader will be able to thread his way through the complexities of the subject, the majority of which are more apparent than real.

It will also be appreciated that the development of mining material and its effective employment in war is closely bound up with the development and employment of the corresponding antidotes. The latter include both minesweeping and the self-protection of ships and it would require a separate volume to do full justice to this aspect of the matter. The present book has therefore been devoted to a consideration of the weapon, confining references to the various countermeasures to that necessary to an understanding of the subject of mine warfare as a whole.

The drawings which accompany the text have been reduced to their simplest diagrammatic form. That is to say, they are intended to illustrate the general principles involved without necessarily representing the details of construction in any shape or form whatsoever.

CHAPTER II

EARLY DEVELOPMENTS

(From 1585 to 1865)

It is a matter of good manners rather than of technical accuracy to state that the first recorded use of mines was in 1585, when the Dutch succeeded in disposing of several hundred Spaniards at Antwerp by means of boats filled with gunpowder and exploded by clock-operated flintlocks. Similar remarks apply to the less successful use of 'floating petards' by the English off La Rochelle in 1628, but it must be pointed out that in neither case did the explosions occur under water, nor did they in fact depend on the presence of an enemy ship.

In modern terms, these devices were 'delay-action floating bombs', whereas the primary purpose of the mine is to attack a ship in the most vulnerable part, below the water-line. This, moreover, is the primary purpose of the torpedo; in the early stages of development many such weapons were so called, and what we now refer to by this name is really the 'locomotive' torpedo. In order to avoid confusion, and in politeness to the early designers, it is intended to use the nomenclature which they themselves adopted.

The War of American Independence (1776)

The pioneer of underwater attack was David Bushnell, an American citizen. Having established that gunpowder could be exploded under water, he proceeded to solve the problem of bringing the explosive charge into contact with the hull of an enemy ship. The answer was a one-man submarine boat, produced in 1776. This was by no means the first submersible craft to be built, but it represented the first attempt to apply the submarine principle to war, and Bushnell is therefore regarded as the father of torpedo and mining warfare as we know it to-day.

Bushnell's submarine was an egg-shaped structure, fitted with a horizontal propeller, a vertical propeller, and a rudder.

Depth was controlled by allowing water to enter a ballast tank or expelling it by means of a pump. The lower end of the structure contained 700 lb. of lead ballast, of which 200 lb. could be slipped in emergency, so bringing the boat rapidly to the surface.

The lethal part consisted of a 'magazine', containing 150 lb. of gunpowder. The magazine was carried outside the boat, but could be released from the inside, and was connected by a stout lanyard to a large screw which could also be operated from inside the boat.

The proposed method of attack was to manœuvre into a suitable position against the hull of an enemy ship, into which the screw was then forced and the magazine released. The act of release started a clockwork mechanism, and the boat drew clear, leaving the magazine secured to the enemy ship by means of the lanyard and screw. Thirty minutes later the clockwork mechanism had revolved sufficiently to allow a hammer to strike a percussion cap and so ignite the gunpowder.

The entire equipment of this ingenious machine was worked by hand, and a successful attack clearly called for a high degree of skill as well as personal courage on the part of the 'operator'.

The first attempt was made by a sergeant named Ezra Lee, the target being the blockading squadron of the English fleet lying off Governor's Island in New York Harbour. Towed to within a few miles of the ships and then slipped, Lee was carried by the tide beyond his objective, but subsequently managed to propel himself alongside the 64-gun frigate *Eagle*, flagship of Lord Howe. Two attempts were made to place the magazine, but it was found impossible to insert the screw into the copper-sheathed hull of the target ship. With the approach of daylight, the intrepid sergeant was forced to withdraw, and he succeeded in escaping after slipping the magazine, which he found to be an encumbrance.

Several further attempts were made against the blockading fleet, but they all failed. Lack of money and official support prevented Bushnell from effecting any improvements in his craft, and he therefore turned his attention to the development of other methods of underwater attack.

In 1777, he made an attempt against the 32-gun frigate *Cerberus* as she lay at anchor between New London and the entrance to the Connecticut River, by 'throwing a machine against the side by means of a line', to quote his own words. The 'machine' was loaded with powder and fired by means of a gun-lock. By some oversight, it encountered a schooner lying astern of the *Cerberus* and demolished her, the only survivor being blown overboard and 'taken up very much hurt'.

In the following year Bushnell released a number of explosive kegs from above the British shipping lying in the Delaware River. Owing to a miscalculation in the distance at which they were released, and the delaying effects of ice, the kegs arrived in daylight and the buoys from which they were suspended could be seen. One blew up a boat whose crew had handled it with insufficient care, thereby giving rise to the events reported as follows in the 1844 edition of the *Annals of Philadelphia and Pennsylvania*:

Among the amusing and facetious incidents of the war, which sometimes cheered the heart amidst its abiding gloom, was that of the celebrated occurrence of the 'Battle of the Kegs' at Philadelphia. It began at early morn, a subject of general alarm and consternation, but at last subsided in matter of much merrymaking among our American whigs, and of vexation and disappointment on the part of the British. When the alarm of explosion first occurred, the whole city was set in commotion. The housekeepers and children ran to their houses generally for shelter, and the British everywhere ran from their shelters to the assigned places of muster. Horns, drums and trumpets sounded everywhere to arms with appalling noise, and cavalry and horsemen dashed to and fro in gay confusion.

The kegs which gave this dire alarm were constructed at Bordentown, and floated down the Delaware for the purpose of destroying the British shipping which all lay out in the stream moored in a long line, the whole length of the city. The kegs were charged with gunpowder, and were to be fired and exploded by spring-lock, the moment the kegs should brush themselves against the vessel's bottom. The kegs themselves could not be seen, but the buoys which floated them were visible. It so happened, however, that at the very time (on January 7th, 1778) when the scheme was set in operation, the British, fearing the making of ice, had warped in

their ships to the wharves, and so escaped much of the intended mischief. The crew of a barge attempting to take one of them up, it exploded and killed four of the hands and wounded the rest. Soon all the wharves and shipping were lined with soldiers. Conjecture was vague, and imagination supplied many 'phantoms dire'. Some asserted the kegs were filled with armed rebels, that they had seen the points of their bayonets sticking out of the bung-holes. Others, that they were filled with inveterate combustibles, which would set the Delaware in flames and consume all the shipping. Others deemed them magic machines which would mount the wharves and roll all flaming into the city. Great were the exertions of officers and men, and incessant were the firings, so that not a chip or stick escaped their vigilance. We are indebted to the facetious muse of Francis Hopkinson, Esq.¹ for the following *jeu d'esprit* upon the occasion:

Those kegs I'm told the rebels hold
Packed up like pickled herring;
And they've come down to attack the town
In this new way of ferrying.

The soldiers flew, the sailors too,
And, scared almost to death, sir,
Wore out their shoes, and spread the news,
And ran till out of breath, sir.

'Arise, arise!' Sir Erskine cries;
'The rebels, more's the pity,
Without a boat, are all afloat,
And ranged before the city.'

The royal band now ready stand,
All ranged in dread array, sir,
With stomach stout to see it out,
And make a bloody day, sir.

Such feats did they perform that day,
Among those wicked kegs, sir,
That years to come, when they get home,
They'll make their boast and brag, sir.

¹ Father of the author of 'Hail, Columbia.'

Several further attempts of a similar nature were made, but the general result was the creation of alarm rather than the infliction of damage, an effect which any new method of attack remains capable of achieving to this day, however crude it may be in itself.

The next notable figure in the development of underwater warfare was Robert Fulton, also an American citizen. A man of tremendous inventive genius over a wide field, he was also profoundly interested in the question of universal disarmament, and his various proposals for underwater attack were in all sincerity designed to ensure the freedom of the seas by rendering surface fleets obsolete.

An opportunity to apply his theories came in 1797. The war of the French Revolution was then in progress, and many of the French ports were under blockade by the British fleet. Fulton was in France, where he had already enhanced his reputation as an inventor. His first device, tried out in the Seine, was intended to give forward movement to a submerged charge of gunpowder, and was in effect a crude form of locomotive torpedo. The results were inconclusive, but Fulton was satisfied that only lack of funds could prevent him from achieving success. He therefore hit upon the novel idea of floating what well might have been called 'A Company for the Destruction of the English Fleet'. To this end he directed the following historic letter to the Directory of France:

CITIZEN DIRECTOR,

Having taken great interest in all that would diminish the power of the English fleet, I have planned the construction of a mechanical engine, in which I have the greatest confidence, for the annihilation of this Navy. Some practice is, however, necessary to perfect the apparatus. The grandeur of the project has incited in me an ardour to share in a demonstration of this engine. To this end, in order to save you all trouble, I have formed a Company which will undertake the expense and carry out the work on the following terms:

1. The French Government undertakes to pay the Company of the 'Nautilus' 4000 francs a gun for every English ship above 40 guns which the inventor destroys, and 2000 francs a gun for every ship below 40 guns, these sums to be paid within 6 months of the destruction of each ship.

2. All the English merchant ships or war vessels captured to be the property of the Company without any hindrance on the part of the Government agents to prove that they are English property.

3. The Government accords to the Company of the 'Nautilus' the monopoly of this invention for all the French ports, that is, if the Government does not wish to construct similar boats. The Government in this case is at liberty to construct as many Nautiluses as it pleases, provided that 10,000 francs are paid for each Nautilus used by the Government.

4. Being a citizen of the United States, I desire it to be stipulated that this invention or a similar one will not be used by the French Government against the United States, or, at least, the Americans must use them first against the French before this stipulation is annulled.

5. If peace is concluded with England within three months of this day the Government will pay the Company all the sums spent on experiments; this to be paid within three months of the signing of peace.

6. As in the case of fire-ships or other contrivances for the destruction of ships which are considered to be against the Laws of War, the people who take part in these enterprises are hung or put to death, the Directory, to prevent this, will accord to the Company of the 'Nautilus' a commission specifying that every person made prisoner in a 'Nautilus', or on one of the Company's expeditions, is to be treated as a prisoner of war, and any hurt done to them is to be met by similar reprisals on English prisoners.

Citizens, as I firmly trust this engine will give liberty of the sea, it is important to experiment as soon as possible so that, if she succeeds, the Terror will be scattered before the invasion of England, and the boat can be employed in assisting this invasion.

In submitting these proposals to your deliberations, and awaiting your orders, I remain, with all possible respects,

ROBERT FULTON.

Many of the provisions of this remarkable document were accepted, but the French Ministry of Marine refused point-blank to grant commissions to the crews. This decision was in general accord with the opinions of naval officers, to whom the suggested method of waging war was anathema. This stigma continued to be attached to underwater attack for many years, and persists in some quarters even to this day.

When challenged, the opponents of underwater attack frequently rely on the argument that the ship attacked is not given a chance to defend herself. The soundness of this argument is open to very grave question, for there are many methods by which a ship can be defended against the torpedo and the mine, some of them direct and some of them indirect. The one thing these methods have in common is that they absorb men and material and as a general rule affect the free movement of ships. From the point of view of those who impose these burdens by the development of underwater attack, nothing could be more satisfactory, and if this attack is properly related to that of the more 'orthodox' weapons the result is a balanced war economy.

The 'stab-in-the-back' charge does not in fact hold water. The achievement of *surprise* is one of the most important principles of war, and the tactical object of every commander is to get his blow in before the enemy has a chance to reply. Admiral of the Fleet Lord Fisher, in his dictum 'hit first, hit hard, and hit often', was in fact dealing with the realities of war, as opposed to the niceties of duelling.

No apology is offered for this minor digression. The plain truth is that much of the objection to underwater attack does not have its origins in any high-principled regard for the dictates of chivalry, but in fear of the consequences of such an attack if practised by the enemy.

To return to Robert Fulton. His 'mechanical engine' was a submersible, and, as in Bushnell's scheme, the idea was to manœuvre beneath the hull of an enemy ship and attach an explosive charge thereto by means of a spike and line. In spite of a favourable report by a French naval commission, Fulton's plans were rejected by the Ministry of Marine. He thereupon laid them before the Dutch Government, but again without success. In 1800 Fulton once more approached the French and succeeded in enlisting the support of Bonaparte. A grant of 10,000 francs was made for the construction of a 'Nautilus' and in 1801 trials took place at a depth of 25 feet. They were comparatively successful, and in August of the same year an old schooner was placed at Fulton's disposal and duly blown up. This was the first recorded case

of a vessel being destroyed in European waters by an explosive charge placed *below* the water-line.

Fulton's proposals were, however, turned down, not on the score of any technical shortcomings, but on the old grounds of moral indefensibility. In May 1804 he left France and placed his ideas before the British Government.

Mr. Pitt, the Prime Minister, was attracted, and appointed a strong commission to investigate the matter. Many experiments were carried out, and amongst other things Fulton produced an 'explosive catamaran', an oblong wooden structure carrying about forty barrels of gunpowder, the whole craft being made watertight with canvas and pitch. The charge was fired by a clockwork mechanism, gun-lock hammer, and percussion cap. In October 1804 these explosive catamarans were used by Lord Keith in an attack on the French fleet off Boulogne, being connected together in pairs and set to drift with the tide. The explosions occurred too near the surface, and apart from some advance in technique there was little to distinguish this effort from that of the Dutch off Antwerp in 1585. It was nevertheless generally regarded as a dastardly performance.

Fulton continued his experiments in England, and in 1805 blew up the brig *Dorothy* off Walmer with a carcass containing 175 lb. of gunpowder, the event occurring about fifteen minutes after the fuse mechanism had been started. The British commission, however, remained opposed to his schemes. Lord St. Vincent made the famous remark which has already been quoted in Chapter I, and in 1806 Fulton returned to America.

In 1810 a committee was appointed in America to consider Fulton's further inventions, which included the 'harpoon torpedo'. The idea was to fire a harpoon into the hull of a ship from a musket. The torpedo, suspended from a float, was then carried by the tide against the hull of the ship, the blow being sufficient to release a spring lock and fire the charge. Experiments were carried out against the frigate *Argus*, which was surrounded by so many nets, booms, and spars as to render her not only immune from this particular form of attack but incapable of being brought into action, in some degree or another a not unusual feature of this type of

naval warfare. Fulton pointed out that the method of protection employed did not defeat the torpedo as such, but only the method of attack practised by him. 'A system', he said, 'which then only in its infancy compelled a vessel to guard herself by such extraordinary methods could not fail of becoming a most important factor in war.' Truly prophetic words.

Proposals were also made at this time for what was in effect the first moored contact mine (Fig. 1). This consisted of a copper case containing 100 lb. of powder. On top of the case was mounted a brass box fitted with a firing lever which, on being struck, actuated a gun-lock and fired a musket charge into the main explosive. Beneath the copper case was lashed a deal box filled with cork to give added buoyancy. The mine was moored

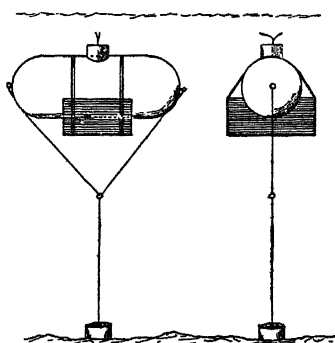


FIG. 1. THE FIRST MOORED MINE

by means of a heavy weight and anchor, and a remarkable feature of the design was an attachment to the deal box which in Fulton's words 'held the mine under water for a day, a week, or a month, and which then locked the firing lever and permitted the mine to rise to the surface and be handled in safety'.

In fact, this mine embodied a number of ideas which in one form or another have been preserved to this day.

In 1814 Fulton produced a peculiar craft referred to as a 'turtle boat' in the official British dispatches. The following is an abridged version of the description compiled from contemporary reports by Commander W. B. Rowbotham, which appeared in the *United States Naval Institute Proceedings* for December 1936 and is understood to be the first published account:

The vessel was invented . . . for the purpose of towing torpedoes to destroy [the English] shipping; it is worked by means of a winch inside, which turns two wheels on the outside, which it is supposed will force her ahead at four miles an hour. She is intended to carry twelve men inside; the bottom of it is similar to that of a boat,

and its top arched like a turtle shell. She is built nearly to the scantling of 100-ton ship and planked outside with 8-inch stuff, cased over with plate iron of half an inch thickness, and is, in the whole, considered so strongly and well constructed that a shot cannot penetrate it, nor can anything grapple with it. It has a scuttle on the top for men to enter, where a lookout man is placed; the hatch is of the same thickness as the vessel and is shut down when in danger. It has two air holes abaft the scuttle and one before. It draws six feet of water and floats one foot above the surface, which is painted dirty white to avoid its being discovered when afloat. . . . It is intended to tow five torpedoes, which are filled with powder and other combustible matter, one of which was tried at New York and blew a vessel of 200 tons all to pieces. The torpedoes have a gunlock inside of each, to which is affixed a line leading down the scuttle. . . . This line is pulled by the men on discovering the torpedo has met a resistance, which is supposed can only be caused by having fouled the vessel which it is intended to fire.

One of these boats, driven ashore in a gale on Long Island while on her way to attack the English squadron under the command of Vice-Admiral Sir Alexander Cochrane, was on the 26 June 1814 successfully destroyed, after a spirited engagement with the opposing militia, by seamen and marines landed from H.M. Ships *Maidstone*, Captain G. Burdett, and *Sylph*, Commander John Kinsman. To the considerable relief of the English, no more of these craft were encountered.

Robert Fulton died in 1815. The majority of his inventions were to prove of lasting benefit to humanity, but his efforts to abolish war by making it too horrible to contemplate only succeeded in hastening the development of one particular form of attack.

Introduction of Controlled Mining (1843)

The year 1843 saw the introduction of controlled mining in the true sense of the term. Colonel Colt, of revolver fame, had for many years been experimenting with mines fired electrically from the shore, and he eventually succeeded in destroying a moving ship some five miles from the land. The correct moment at which to fire was signalled to an observation post by the closure of an electric circuit on contact being made between the ship and the mine.

During the Schleswig-Holstein war of emancipation (1848-51) electric observation mines devised by Professor Himmly of Kiel University were used for the defence of Kiel Harbour, thereby deterring the Danish fleet from forcing an entry, but it was not until the Crimean War that a carefully planned system of defensive minefields was employed.

The Crimean War (1854-6)

During this war mines were used by the Russians for the defence of their principal harbours—Sevastopol, Sveaborg, and Kronstadt.

The mines, which were of the contact type, have been attributed to Professor Jacobi. He, no doubt, had a hand in the design, but the real inventor was more probably Nobel, the father of Alfred Nobel. In any case, the fuses were of an extremely ingenious type, comprising a glass tube filled with sulphuric acid and embedded in a mixture of chlorate of potassium and sugar. The whole fuse was enclosed in an outer tube of lead, the end of which protruded from the mine-case. On the lead tube being bent by contact with the hull of a ship, the inner glass tube was fractured, the acid came into contact with the chemicals and the resulting heat and flame fired the main charge, which consisted of 25 lb. of gunpowder.

This system was the forerunner of the 'Herz' horn, to be described later, and which for many years was to be the most reliable method of firing a contact mine.

H.M. Ships *Merlin* and *Firefly* were both severely damaged by mines off Kronstadt, and many Russian mines were recovered and rendered safe under hazardous conditions.

The Russians also made use of mines laid on the sea-bed and fired electrically from the shore. In order to produce the necessary explosive effect, very heavy charges were required, and considerable difficulty was experienced in determining the correct moment at which to fire.

This latter difficulty, inherent in most forms of controlled mining, was tackled by a Major Ebner of the Austrian Army during the war of 1859 between France and Austria. He devised a form of camera obscura, whereby the movements of an enemy ship were projected on to a chart which had

marked on it the exact position of each individual mine. At the correct moment the appropriate mine was fired electrically from the control-room, a method which worked admirably on a bright clear day, but was of no use by night or in foggy weather, a disadvantage shared by all systems of visual observation. Colt's method overcame this difficulty, but it involved contact between the enemy ship and a mine, and was therefore unsuited to the defence of channels in use by friendly ships of any importance. Although the mines could be put to 'safe' for the passage of such ships, there was always the risk of damage to propellers, etc., to say nothing of the probable removal of part of the defences every time a friendly ship entered the harbour.

The American Civil War (1861-5)

A considerable use of mines was made during the American Civil War. The Confederates, being numerically inferior to the Federals in the matter of ships, were from the naval point of view the weaker power and their employment of mines as a method of redressing the balance was thus in accord with a principle which, although sound enough in itself, was subsequently to be misconstrued by Great Britain. In view of their bearing on the development of mine warfare, it is thought profitable to refer to some of the operations in detail.

For example, in preparation for the attack on Vicksburg in December 1862, the River Yazoo was reconnoitred by Federal gunboats. Many 'torpedoes' were seen, and two light craft were therefore sent ahead to remove them or sink them by gunfire. This was a perfectly good plan, but one of the heavier gunboats, mistaking the resulting fusillade for an engagement with hostile forces on the river bank, closed up in support. Two mines exploded beneath her and she sank in twelve minutes.

These particular mines were no more than small kegs filled with powder, the latter being ignited by simple friction primers of a type similar to those used to-day in Christmas crackers. The original intention had been to fire them by pulling a wire from the shore, the wire being attached to the primer and passing through a water-tight bung on top of the

keg, but the majority of these devices were moored in pairs, with the primers of each pair connected by a wire.

The defences of Mobile, to quote another example, were strengthened by the laying of a triple line of mines of various types. One type consisted of a keg with coned ends, filled with powder and well caulked to prevent the entry of water. Five chemical fuses were fitted, similar to the type evolved by Jacobi and Nobel. Another type was constructed of metal in the shape of an inverted cone (Fig. 2), the original design being attributed to a Mr. Singer. The explosive, of gunpowder, was carried in the lower half of the case, while the top carried a cast-iron weight capable of being dislodged by a slight blow. This cover was connected to a friction tube by means of a chain, and on being knocked off by a moving ship the resulting pull on the chain fired the friction tube and so exploded the charge. The design was of further interest in that it incorporated a safety device, a feature which until that date appears to have been regarded as somewhat effeminate. It will be noticed in Fig. 2 that *two* bights of chain are shown. One link of the second and slightly shorter chain was secured to a rod which passed vertically through the mine, and through this rod there passed a safety pin to which a small float was secured by means of a line. If the cover was knocked off by accident while the mine was in transit or in the process of laying, the weight was taken by the safety pin and not by the friction tube. After laying, the mine was rendered dangerous by a gentle tug on the float line, which withdrew the safety pin and released the short bight of chain. This simple arrangement complied with nearly all the safety requirements laid down for the modern mine. A development of this type of mine (McEvoy's patent) is described in the early editions of the official Admiralty handbook on the subject, and its preparation and laying was in fact taught at the Torpedo Schools.

The minefield off Mobile comprised some eighty mines of

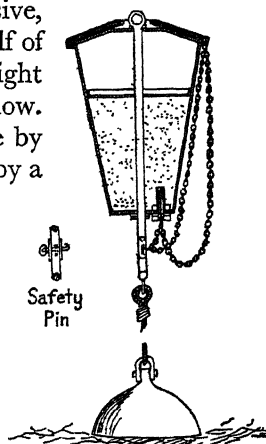


FIG. 2. SINGER'S MINE

the two types described above. In making his attack, Admiral Farragut placed his ironclad monitors at the head of the line, and the wooden ships astern. The leading monitor struck a mine and sank with considerable loss of life. The *Brooklyn*, sighting more mines, altered course and warned the flagship *Hartford* of the danger, whereupon Admiral Farragut is alleged to have made one of the most famous remarks recorded in the history of sea warfare: 'Damn the torpedoes! Captain Drayton, go ahead. Mr. Jowett, full speed.' Whether he was correctly reported is of little moment, but in the actual event his gallantry was rewarded, for although several ships felt the mines scrape along their sides, corrosion had rendered their firing mechanisms ineffective. In the subsequent mine-clearance operations, however, many small craft were destroyed.

Another type of mine, the Brooks, consisted of a case containing 100 lb. of gunpowder and mounted on the end of a solid spar (Fig. 3), the other end of the spar being connected to a weight by means of a universal joint. The mine

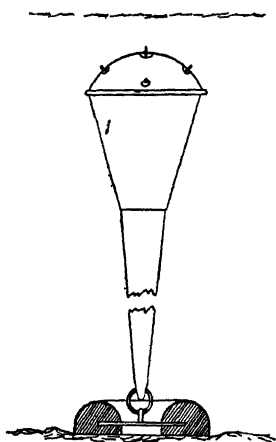


FIG. 3. BROOKS' MINE

was intended for use in shallow water, and was extremely difficult to sweep, this difficulty being increased on occasion by running a wire to a second mine lying on the bottom and containing a heavy charge of explosive. On any attempt being made to deal with the upper mine, the resulting pull on the wire fired the large ground mine through the medium of a simple friction tube, so destroying the sweeping craft. This combination, known locally as the 'devil circumventor' was the first practical example of an anti-sweeping device. It seems probable that its only defect was a tendency to suicide, due

to the trip-wire of the ground mine becoming entangled with the spar mooring of the buoyant mine, but this may not necessarily have been so, as the mines were normally used in rivers where the current always ran in the same direction.

Towards the end of the American Civil War, some use was made of ground mines fired electrically from a distance, and the heavily armoured Federal gunboat *Commodore James* was destroyed by this means in the Roanoke River, the mine consisting of an old boiler filled with 1,000 lb. of gunpowder. An interesting feature of this operation was that searches carried out along the river banks for the electric cables were frustrated by the simple expedient of shifting their position during the hours of darkness. In January 1865, to counter the nightly attacks made by Federal gunboats off Charleston, a line of mines was laid by the Confederates across their path, and as a result the *Patapsco* was sunk with heavy loss of life.

The Davids

So far, in dealing with the American Civil War, these notes have been confined to a consideration of mines in the more modern sense of the term, i.e. static weapons to which the enemy must come. The locomotive torpedo had not yet been developed, but so desperate was the plight of the blockaded Confederate states that the hazards still inherent in the operation of bringing an explosive charge to an enemy ship were held to be acceptable.

This led to the construction of various small craft generically known as 'Davids'. They were not submarines in the sense that they could submerge completely, but were so constructed that by taking in water ballast they could run in an awash condition with very little of the hull showing above the surface.

Some were propelled by hand, and others by steam (Fig. 4), and their weapon of offence consisted of a 'spar torpedo', comprising a copper container filled with 134 lb. of gunpowder and fired by chemical fuses when brought into contact with the hull of a ship. On the night of 5 October 1863, one of these craft, commanded by Lieutenant Glassell, succeeded in damaging the Federal *Ironsides* in Charleston Harbour. Another, in February 1864, sank the *Housatonic* in the same area. Subsequently the *Minnesota* and the *Memphis* were damaged, but in general the 'Davids' were considered to be inferior to small surface craft armed with spar torpedoes, which were used by both sides, the torpedoes either being exploded on

impact by chemical fuses or by a gun-lock to which a firing line was attached and led inboard. A daring attack of this nature was made on the Confederate ship *Albemarle* by Lieutenant Cushing, an extract from whose official report reads as follows: 'The light of a fire ashore showed me the

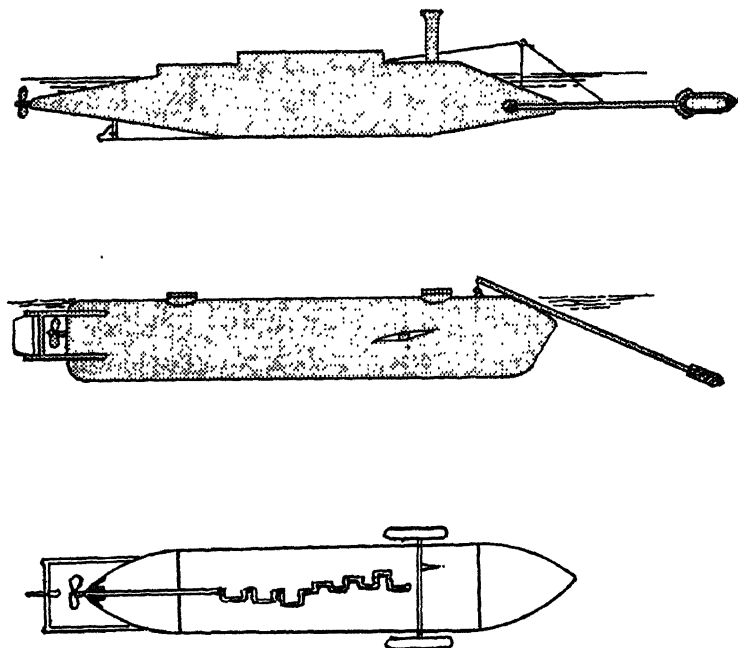


FIG. 4. THE 'DAVIDS' WITH SPAR TORPEDOES

ironclad made fast to the wharf surrounded by a pen of logs about thirty feet from her side. We made for our enemy at full speed. In a moment we had struck the logs just abreast of the quarter-port, breasting them in some four feet and our bows resting on them. The torpedo boom was then lowered, and by a vigorous pull I succeeded in driving the torpedo under the overhang and exploded it at the same time as the *Albemarle's* gun was fired. A shot seemed to go crashing through my boat and a dense mass of water rushed in from the torpedo, filled the launch, and completely disabled her. The enemy then continued his fire at fifteen foot range, and demanded

our surrender, which I refused, ordering the men to save themselves. The most of our party were captured, some drowned, and only one escaped besides myself.' This was William Hoftman, seaman, of the *Chichoppee*.

The skill and determination displayed in this attack was to be repeated some eighty years later in exploits of the British midget submarines, to which reference will be made in due course.

In all, some twenty-two combatant ships were destroyed by various types of mine during the American Civil War, and many others damaged. The mine had ceased to be a gadget and in some form or another was thenceforward to play a part in naval warfare.

CHAPTER III

FURTHER DEVELOPMENTS

(From 1865 to 1914)

As hinted at the close of the previous chapter, the end of the American Civil War represented a landmark in the development of underwater warfare. Starting with the fundamental principle that the most vulnerable place to attack a ship is beneath the water-line, we have so far noted the application of this principle in five main ways:

- (a) By drifting charges suspended from a float.
- (b) By charges moored in the path of an enemy ship, and fired either by contact or electrically from the shore.
- (c) By charges fixed to the hull of a ship and exploded by a time mechanism.
- (d) By charges towed against the hull of a ship.
- (e) By charges carried on the end of a spar.

Of the above, methods (a) and (b) were to survive. Methods (c), (d), and (e), whose primary purpose was to remove the 'operator' from the immediate vicinity of the explosion, were to lapse.¹ The submarine had emerged from the chrysalis stage, and in 1867 the locomotive torpedo was invented. The combination of the two was of immense value, in that it enabled a *moving* ship to be attacked without warning from a comparatively safe distance, and the mutual interaction of the craft and the weapon led to improvements in both. The remainder of this book can therefore be devoted to a consideration of the mine proper, and this chapter is intended to present a chronological summary of development up to the beginning of World War I.

In so far as the British Empire was concerned, it was decided to augment the defences of the principal harbours by systems of controlled minefields. These systems, under the

¹ In actual fact, spar torpedoes fitted to picket boats and steam pinnaces were retained in the British Navy for some years, and mention should also be made of the Harvey Towing Torpedo. The latter was never issued to the fleet.

direction of the War Office, were most efficiently developed by the Royal Engineers. Concurrently, the Royal Navy developed a system for the rapid defence of a temporary base, and for some years the laying of controlled mines for this purpose formed an integral part of fleet training. The early official handbooks on the subject describe a variety of controlled mines, but those finally adopted for harbour defence were of two main types:

(a) The 500-lb. observation mine, fired electrically from the shore.

(b) The 76-lb. electro-contact mine.

In the former type, the correct moment at which to fire was established either by direct observation along a line of aiming marks, or by cross-bearing from two observers each provided with a firing key, or by means of a 'Depression Position Finder'. This instrument consisted essentially of a telescope mounted in a control station overlooking the mine-field and fitted with a spring plunger which moved over a set of contact strips as the movements of an approaching enemy ship were followed. These strips were connected to the firing circuits of the mines or groups of mines, the circuit from the battery to the correct group being completed simultaneously with the passage of the enemy ship over that group (Fig. 5).

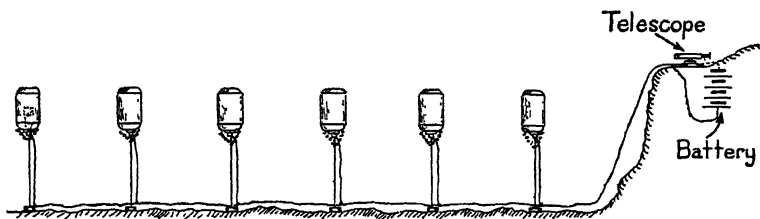


FIG. 5. AN OBSERVATION MINEFIELD

In the electro-contact type, the firing battery could be put 'on circuit' whenever it was required to bring the defences to the ready. On being struck by a ship, the mine fired due to the circuit being closed either by the movement of an inertia weight or the displacement of a small quantity of mercury (Fig. 6). The explosive charge in both these mines was

guncotton, adopted by Great Britain in 1870. Other countries developed along similar lines, the observation mines being either of the buoyant or the ground type.

During the Austro-German War of 1866 the coasts of Istria

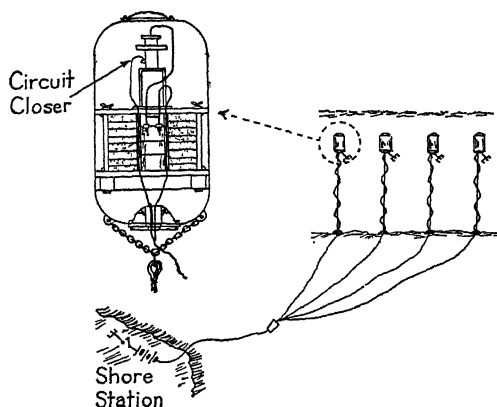


FIG. 6. AN ELECTRO-CONTACT MINEFIELD

and Dalmatia were defended by very elaborate systems of mines, and in 1868 the Herz horn method of firing independent mines was invented by Dr. Herz of the German Mine Defence Committee. This method, a development of that already noted in connexion with the Crimean War, was one of the most important in the history

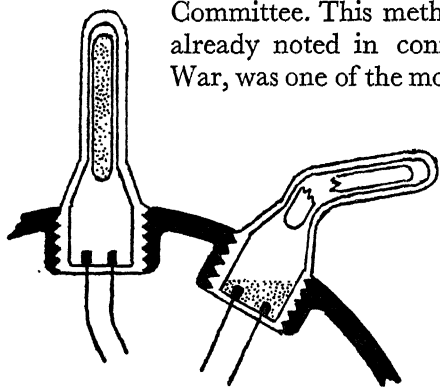


FIG. 7. THE HERZ HORN

of mine warfare. The Herz horn (Fig. 7) embodies the essential components of an electrical battery, e.g. a carbon plate, a zinc plate, and a bichromate solution, the latter contained in a sealed glass tube inside a lead horn. On the horn being bent, the glass tube

is fractured and the liquid comes into contact with the zinc and carbon plates. This completes the battery, and a potential of about 1·8 volts is produced, sufficient to fire an electric detonator.

The latter consists of a bridge of thin platinum wire embedded in fulminate of mercury. The current from the Herz horn battery fuses the platinum wire bridge; this ignites the priming composition of the detonator, which detonates the main charge through the medium of a primer of dry guncotton.

The supreme advantage of the Herz horn is that the initial firing energy is stored chemically and not electrically. The horn thus has an effective life of indefinite length, and will function after many years in store followed by months in a mine. Nevertheless, such was the prejudice in Great Britain against the use of an electric current, however derived, for the firing of independent mines, that we did not adopt this method until forced to do so in World War I.

During the Franco-German War of 1870 the Jade, Elbe, and Weser Rivers were protected by mines, and thereafter Germany took up the development of mining material with considerable vigour.

In 1873 an Admiralty Torpedo Committee was set up in this country, and extensive explosive trials were carried out against H.M.S. *Oberon*, an old paddle-wheel ship of 950 tons, with her hull strengthened to represent that of H.M.S. *Hercules*, at that time the most strongly constructed ship in existence.

In so far as the mines were concerned, in their report issued three years later the Committee confined themselves to a consideration of the two types already standardized for *protective* purposes, and generally agreed to be essential adjuncts to the gun defences of a harbour.

The Royal Navy, as already stated, had adopted these mines for the rapid defence of a temporary fleet base, and had also developed the *countermine*. This involved the running, from a specially rigged launch, of a line of electrically fired mines in the vicinity of a minefield laid by the enemy for the protection of one of his own harbours, with the object of detonating them or rendering them mechanically ineffective. The seamanship problem involved in this performance, to say nothing of the technical complexity, needs no emphasis, but for many years this was to remain one of the principal methods of dealing with enemy mines, the alternative in the

case of controlled mines being to creep for the electric cables with grapnels fitted with explosive charges.

It may be of interest to interpolate here that in 1885 Lieutenant Ottley, the Torpedo Officer of H.M.S. *Nelson*, reported that he had improvised a form of land-mine, while in the same year a report was received from Lieutenant Talbot of H.M.S. *Carysfort* that, assisted by H.M. Ships *Briton* and *Dolphin* he had produced a similar device at Suakin. Thus, presumably, was the anti-tank mine born, although in 1882 Lieutenant Dicken had been commended by Captain J. A. Fisher, Commanding the Naval Brigade, for his zeal and ingenuity in the construction of anti-train mines at Alexandria.

From 1886 onwards much experimental work on independent mines was carried out in H.M.S. *Vernon*,¹ the Torpedo School at Portsmouth, the two most notable results being the 'electro-mechanical' or E.M. mine and the 'automatic sinker'. The former consisted of a 76-lb. electro-contact mine, as standardized for harbour defence, but with the electrical battery fitted inside the mine instead of in the control station ashore, the original inertia or mercury circuit-closer being retained. The system was clearly too sensitive for use in any but the calmest conditions, and was never adopted for service.

The automatic sinker, designed by Lieutenant Ottley, was the outstanding British contribution to the development of mine warfare during this period. Prior to its introduction, all mines were laid with fixed moorings. This meant that they were either laid at varying depths below the surface of the sea, or that a very careful survey of the sea-bed had to be carried out and the mooring ropes cut to fit the depths of water, individual mines then being laid in the positions appropriate to the length of mooring. The object of the automatic sinker was to enable mines to be laid at a pre-determined distance below the surface of the water, irrespective of variations in the actual depth. The original design did not give a very uniform performance, and was modified in this and other countries to produce the Plummet system of automatic

¹ In 1872 H.M.S. *Vernon* had been added to H.M.S. *Excellent*, the Gunnery School, but in 1876 she was commissioned as an independent command.

depth-taking. In this system (Fig. 8) the mooring rope is carried on a drum inside the sinker. The mine remains on the surface while the sinker is descending, the mooring rope drum being free to revolve, and a pawl being kept clear of a ratchet fitted to the drum by virtue of the tension in the

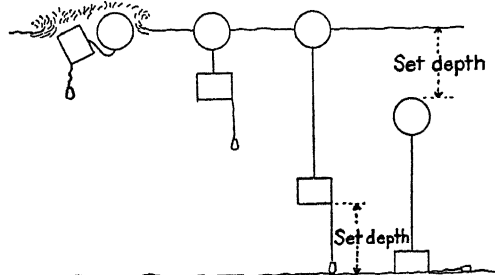


FIG. 8. THE PLUMMET SYSTEM OF AUTOMATIC DEPTH-TAKING (NON-BUOYANT)

plummet wire, the length of which is equal to the depth below the surface at which it is desired to lay the mine. On the plummet striking the bottom, the tension in the plummet wire is relaxed, and a strong spring engages the pawl in the ratchet, thereby locking the drum and enabling the weight of the sinker to drag the mine beneath the surface to a distance equal to the length of the plummet wire.

In this system, known as the 'non-buoyant' unit, it will be noted that the sinker was parted from the mine immediately on laying. As a result, an indeterminate amount of wire was hauled off the mooring drum before the system settled down, with a consequent risk of inaccurate depth-taking at other than very low speeds of ship.

Although not developed until later, it will be convenient as a matter of comparison to describe here the alternative system of automatic depth-taking, known as the 'hydrostatic'. In this system (Fig. 9 (b)), the mine and sinker go to the bottom together. The mine is then released by means of a soluble plug or other timing device and rises to the surface, taking with it a hydrostat to which is attached a pilot wire. On the mine reaching the depth below the surface to which the hydrostat has been adjusted, the latter operates due to the

pressure of water at that depth and the resulting pull on the pilot wire engages a pawl in a ratchet on the mooring rope drum, so locking the drum and mooring the mine at the pre-set depth. Other methods of applying this principle are also shown in Fig. 9.

In 1890, and again in 1891, following representations made

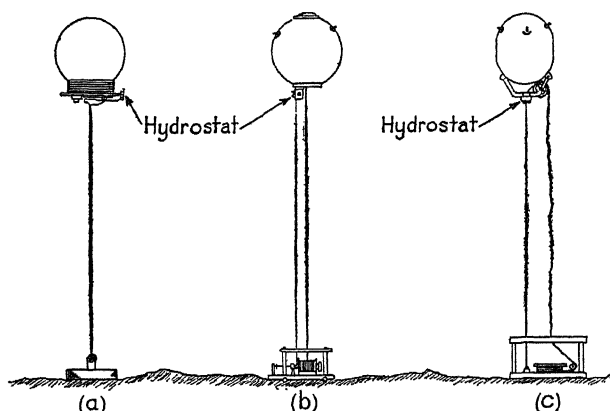


FIG. 9. THE HYDROSTATIC SYSTEM OF AUTOMATIC DEPTH-TAKING

by the Commander-in-Chief, Mediterranean Fleet, experiments with independent mines were put in hand with the particular object of evolving something better than the electro-mechanical mine referred to above, and numerous ingenious methods of actuation were evolved. Much work was also done in the fleet on the development of small mines for laying from boats for the temporary defence of an anchorage. In 1894, however, *it was decided to abandon independent mining*, the electro-mechanical mine being retained for experimental and training purposes. In other countries, development continued, and more particularly in Russia, who by 1898 had accumulated stocks of well-designed independent mines, with Herz horn firing and automatic depth-taking. During the Spanish-American War of the same year, mines were used by the Spaniards for the defence of Santiago and other ports,

and some American harbours were similarly defended. The mines chiefly used were of the independent type, a procedure likely to prove more of an embarrassment than a help in the close approaches to a friendly harbour. No casualties are reported to have been suffered by either side, but the Americans made use of counter-mines to assist forcing the passage to Santiago.

In 1900 the Commander-in-Chief, Mediterranean, again pressed for the provision of Independent mines, and H.M.S. *Vernon* was directed to produce a design. In March 1903, however, development was again abandoned. Countermines, observation, and electro-contact mines were retained as naval weapons, although considered to be of doubtful value, but controlled mining as a permanent method of coast defence was abolished and the Royal Engineers Corps of Submarine Miners was disbanded.

In announcing this decision, the War Office made it clear that no sort of reflection was cast on the efficiency of the material or of those who operated it, nor had any conflict of opinion arisen with the Admiralty as to the layout of the defences of various harbours. As a major question of Imperial Defence policy, however, it was felt that the ability of controlled mining defences to stop a determined attack by numbers of torpedo craft was open to doubt, while the increased range of guns rendered such defences unnecessary. It was, however, considered that the laying of any type of mine was a naval operation, and that the provision of such defences as and when required should rest with the Admiralty.

The author has no quarrel with these views, but he would like to record his disagreement with the opinion that defensive mining was bad for morale.

With regard to independent mining, the decision was influenced by the current axiom that the principal aim of the fleet was the destruction of the enemy, and that the laying of 'blockade' mines, as they were then called, would prevent the achievement of this aim. Alternatively, it was argued that blockade mines could not in fact seal an enemy up in his harbours, and were therefore useless. The possibility that the delay caused by the laying of mines might enable a suitable

concentration of British forces to be effected does not seem to have carried any weight, and the whole controversy was an outstanding example of the danger of catch-phrases on the one hand, and of titles which do not mean anything on the other.

The Russo-Japanese War

The Russo-Japanese War, which broke out in February 1904, saw the first extensive use of independent or open-sea mining, and thus had a profound effect on the development of this type of warfare.

The Japanese mines, laid on automatic sinkers, contained a charge of *shimoze* powder, and were fired by the movement of an inertia weight (Fig. 10). Safety before and during laying

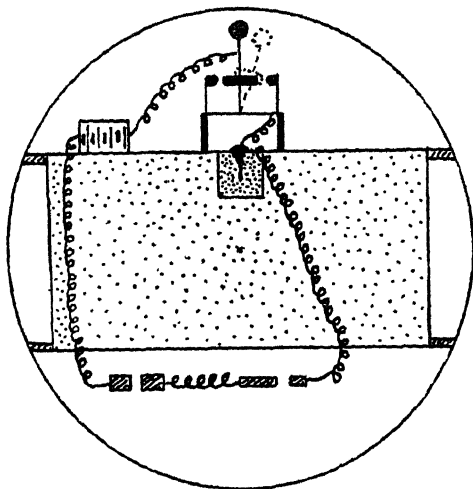


FIG. 10. JAPANESE MINE

was achieved by two circuit-breakers. The first, operated by clockwork, closed one break in the circuit from the firing battery to the detonator between thirty minutes and one hour after laying the mine, the second break being closed by the melting of a soluble plug. The mine was then dangerous, and on being struck by a ship the movement of a heavy pendulum weight caused a ring mounted on the stalk of the pendulum to complete the firing circuit through one or other of four contacts symmetrically disposed outside the ring.

The Russian mines (Fig. 11), were laid on automatic sinkers and contained charges of guncotton. Five Herz horns were fitted, the safety device comprising a hand-operated switch fitted in one of the common leads running externally from a terminal plug in the mine shell to the detonator.

At the very outset of the war, Russian naval strength in the East was seriously reduced as a result of attacks by Japanese torpedo-boats, and it was therefore decided to mine the entrance to Talienwan Bay to cover the approaches to the port of Dalny, and to lay observation mines for the protection of Port Arthur. In the second week of April 1904 the Japanese succeeded in bringing off a brilliant minelaying coup. A mixed force of minelaying craft, including destroyers and torpedo-boats and the converted merchant vessel *Koryo Maru*, laid mines off Port Arthur. Their movements were screened by a dummy torpedo attack, but were in fact observed and plotted by the Russians. On the following day, the Russian fleet was lured to sea by a decoy squadron, the main Japanese fleet being out of sight below the horizon. On the latter making its presence known, the Russian fleet declined action, having been skilfully led into such a position that it would probably encounter the Japanese mine-fields while returning to harbour. This in fact occurred, the Russians in the excitement of the day having presumably forgotten the movements of the enemy minelayers observed during the previous night. Admiral Makaroff's flagship, the 11,000-ton *Petropavlovsk* struck one or possibly two mines and sank almost immediately with heavy loss of life. The 13,000-ton battleship *Pobieda* was also severely damaged, but succeeded in reaching harbour.

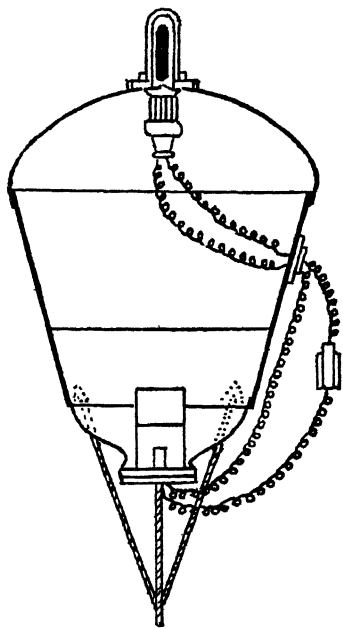


FIG. 11. RUSSIAN MINE

On the night of 3 May 1904 the controlled mine defences of Port Arthur came into action when a determined attempt was made by the Japanese to sink blockships in the entrance. Several of the blockships passed through the gap between two groups of electro-contact mines, and one or two crossed the minefield in safety. Others were sunk, probably by mines, although possibly due to the blowing of their scuttling charges under the impression that they had penetrated further into the entrance than was in fact the case.

The Japanese were shortly to sustain a blow of even greater severity than that inflicted by them on the Russians in April. The movements of their forces off Port Arthur had been carefully observed by the captain of the Russian minelayer *Amur*, and on his initiative a minefield was laid in the area normally traversed by the blockading ships. An immediate success was achieved, for on 15 May 1904 the Japanese battleships *Hatsuse* of 15,000 tons and *Yashima* of 12,000 tons were both mined, the former sinking and the latter having to be abandoned in the vicinity of Encounter Rock while making her way back to Japan. The Japanese subsequently carried out some rather hazardous mine-sweeping operations in this area, but this did not prevent the cruisers *Miyako*, *Takasago*, and *Sai Yen* from being mined. It is believed that at least one of these disasters was due to the Russians altering the positions of the buoys laid by the Japanese to mark the swept area.

On 23 June 1904 the 11,000-ton Russian battleship *Sevastopol* proceeded to sea to counter the activities of the Japanese cruisers operating off Port Arthur. She was damaged by a Japanese mine, and suffered a similar fate in September of the same year, the damage on this occasion being severe. The Japanese also laid a large number of mines off Vladivostock before proceeding to intercept the Russian Baltic Squadron on its appearance from the south, and the Russian cruiser *Gromoboi* was damaged on one of these mines.

In the battle of the Yellow Sea on 10 August 1904 it was reported that the Japanese destroyers had laid mines ahead of the Russian fleet, but, as the official history rightly points out, an action so likely to embarrass if not endanger his own ships is unlikely to have been taken by Admiral Togo.

In addition to the specific minelaying operations referred to, the Japanese employed picket boats and other small craft in numerous minelaying sorties off Port Arthur, the neighbourhood becoming an arena for the battle between the opposing minelaying and minesweeping forces.

In all, Japan lost two battleships, four cruisers, two destroyers, one torpedo boat and one minelayer, the latter (*Yenisei*) on her own mines, while the Russians lost one battleship, one cruiser, two destroyers, one torpedo boat and one gunboat, a truly formidable debut for the independent mine laid in the open sea.

As a result of the Russo-Japanese War, it was once more decided to develop and standardize an independent mine as a British naval weapon. The type produced was known as the 'naval spherical mine' (Fig. 12). In 1905, orders were placed for 1,000 of these mines, with plummet type sinkers. The electro-contact and observation mines were withdrawn from service, but the old electro-mechanical mines were still retained for instructional purposes, being finally scrapped in 1907 when stocks of the new standard mine became available. At about the same time, serious consideration began to be given to the question of mine-sweeping. During the Russo-Japanese War, some rather crude methods had been evolved for towing a bight of wire between two vessels, the wire being kept down by means of iron sinkers, and consequently liable to frequent parting due to rocks, and also extremely difficult to keep properly spread. In 1906, proposals were made by Captain Ogilvy for a sweep in which the wire was spread by means of otters similar to those used in fishing craft, and considerable time and energy was devoted to the evolution of a suitable system. As a corollary, H.M.S. *Vernon* in 1907 recommended the abolition of the old system of counter-mining as being impossible to carry out in war and unnecessary for post-war mine clearance operations.

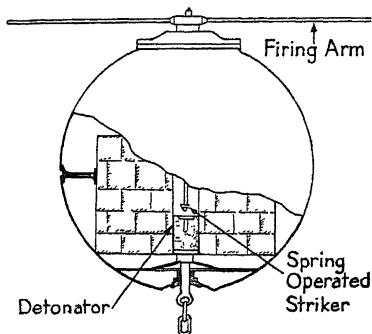


FIG. 12. THE BRITISH NAVAL SPHERICAL MINE

This was agreed, and in 1908-10 twelve gunboats of the *Jason* class were equipped and commissioned as fleet minesweepers. A Trawler Reserve was also inaugurated, courses in mine-sweeping established and a handbook issued on the subject.

In addition to bringing to notice the operational value of the independent mine, the Russo-Japanese War had also raised the legality of this form of warfare when practised in the open sea, particularly with regard to the safety and rights of neutral shipping. This question, hotly debated at the Hague Conference in 1907, is dealt with in detail in Chapter IX.

Up to 1912, efforts in Great Britain were directed to improving the new mines, their sinkers, and their firing gear. Some improvement in the performance of the 'non-buoyant' unit for plummet depth-taking was later effected by keeping the mine and sinker together until they had reached a pre-set depth and then releasing the mine hydrostatically to return to the surface, while the sinker continued to descend. Even so, speed of laying was still restricted.

The original firing gear, of the inertia type, was found to be too sensitive, and so liable to premature firing in a seaway, and in 1913 a new design was approved, in which the movement of an external firing lever released a cocked spring, and so fired a percussion detonator. It should be noted that the cocked spring was a fundamental weakness from the safety point of view, as it virtually involved the firing mechanism being in a dangerous condition during its insertion in the mine when being prepared for laying.

With regard to minelayers, seven old light cruisers of the *Apollo* class were converted to carry 100 mines each (Plate I (a), p. 51), and in 1912 designs for a smaller type of mine to be laid by destroyers were put in hand.

Other Powers, and in particular Germany and Russia, had been actively engaged in the development of mining material since 1904, and in 1914 the general position in so far as the principal belligerents were concerned was as follows:

Great Britain

We had in stock about 4,000 naval spherical mines, of which the firing pistols were in process of modification. Several

foreign types of mine had been tried out during the previous year, but had not been adopted. The most noteworthy were the Carbonit and the Leon. The former, produced commercially in Germany, was a moored contact mine with a charge chamber carried below a large buoyancy chamber (Fig. 13). The mooring rope drum was fitted to the charge chamber and automatic depth-taking was effected by means of a hydrostatically operated grip which locked the mooring rope on the mine rising to its set depth. The drum carried 55 fathoms of mooring rope and depth-taking was very accurate, but the combination as a whole was rather top-heavy and unhandy. Five horns of the Herz type were fitted and the charge consisted of 220 lb. of T.N.T.

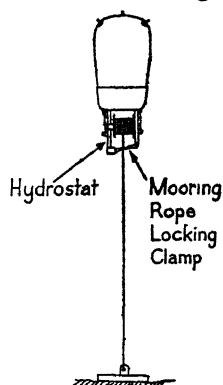


FIG. 13.
THE CARBONIT MINE.

The Leon was an oscillating mine of Swedish design (Fig. 14), which on being laid sank slowly until just below the set depth. A hydrostatic valve then closed and completed the circuit from a battery to a small electric motor driving a propeller at the lower end of the mine and so forcing the latter towards the surface. When just above the set depth the hydrostatic valve again operated, the electric motor stopped, and the mine began to sink again. This cycle of events was repeated until the battery was exhausted or finally switched off by a timing device. Firing was by an inertia pistol.

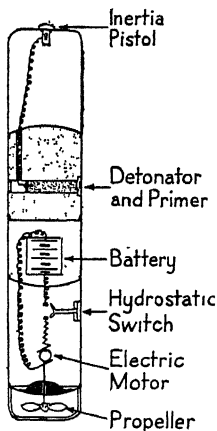


FIG. 14.
THE LEON MINE

In addition to the above, a moored mine produced by Messrs. Vickers was also under trial and considerable work had been done on a type of oscillating mine devised by Lieutenant Sandford.

Minesweeping technique and training was fairly well advanced, but the only minelayers were the seven converted cruisers referred to above.

Germany

Germany had decided to use independent mines to the fullest possible extent, employing every type of vessel for the purpose, and to incorporate controlled minefield systems in the defences of her harbours.

She had accumulated large stocks of buoyant contact mines fitted with Herz horn firing gear and a charge of 160 lb. of guncotton. The design was good, but, in accordance with German practice, it called for an exceptionally high standard of materials and workmanship. Depth-taking was by hydrostat, the mooring rope running from the sinker through a set of jaws on the mine and back to a drum on the sinker (Fig. 9 (c), p. 30). On the hydrostat operating, the mooring rope was gripped by the jaws, thus mooring the mine. The disadvantage of this system lay in the fact that the mine had to support double the weight of wire when moored. All German battleships and cruisers, and a large number of destroyers, were fitted to lay mines, as were certain auxiliaries, such as the *Koenigen Louise*. Considerable attention had also been paid to the laying of mines by submarines.

Russia

Russian policy was identical with that of Germany, and she possessed large stocks of independent mines, ranging from her earlier designs with horn firing gear and an explosive charge of 160 lb. to her satisfactory 1912 design with inertia firing gear and a charge of over 280 lb. of T.N.T. The only criticism of this mine that could be advanced was that it appeared to be more suited to the comparatively shallow and tideless waters of the Baltic than to the conditions of the North Sea. Extensive controlled mining systems were also planned for the defence of Russian harbours, and stocks of mines were available. All cruisers and many destroyers were fitted to lay mines, and laying from submarines had been under trial.

France

France had never displayed any great interest in mining, and on the outbreak of the war she possessed small stocks of independent mines of the following types:

Sauter-Harlé. This mine shared with the Italian *Bollo* type the distinction of being the only example of the use of hydrostatic pressure to actuate the firing mechanism (Fig. 15).

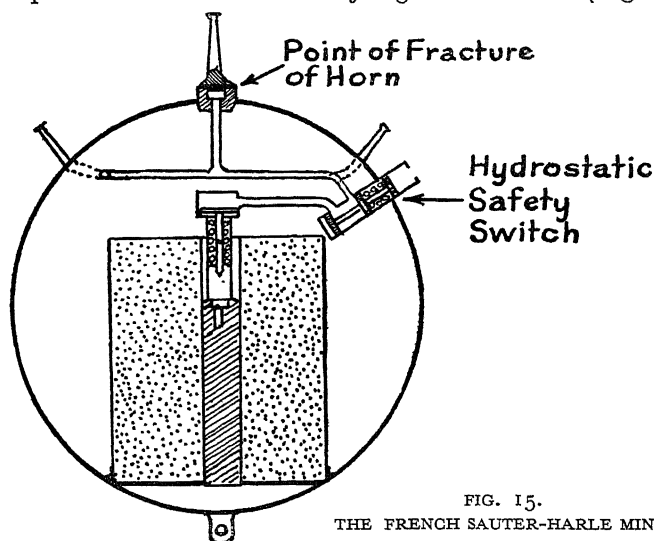


FIG. 15.
THE FRENCH SAUTER-HARLÉ MINE

The fracture of any one of the horns admitted water to a switch, the pressure releasing a cocked spring, which forced a striker into a percussion detonator. Another type of Sauter-Harlé mine was fired by means of an inertia switch.

Breguet. In this mine a pin was sheared and a cocked spring released by the movement of an external firing 'bridle' (Fig. 16).

Schneider. This mine was under development for laying from the deck of a submarine, but was never used.

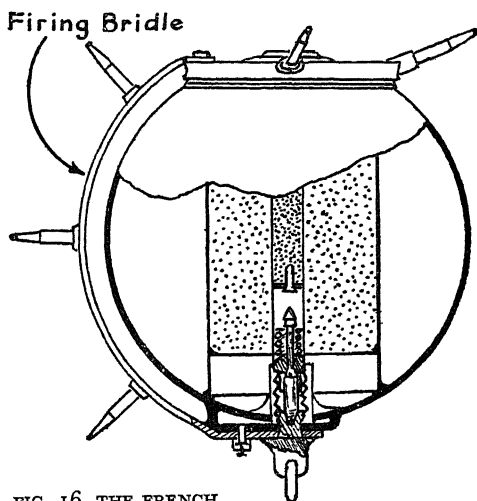


FIG. 16. THE FRENCH
BREGUET MINE

A small number of French ships of various classes were equipped to lay mines, but France was the only maritime nation which had not adopted any system of controlled mining, her policy being to use independent mines for harbour defence should the need arise.

Japan

As a result of the experience gained in the Russo-Japanese War, it would have been reasonable to find Japan in the forefront of development, but such was not the case. Broadly speaking, her policy was to retain small stocks of independent mines for use in enemy waters, and large stocks of observation mines for the defence of her harbours. Her independent mines were of the electro-mechanical type, fired by the movement of an inertia weight. They carried about 70 lb. of explosive, and the design differed but little from that employed in 1904, which has already been described. For laying mines, Japan relied on the conversion of suitable merchant ships.

Turkey

Turkey possessed small stocks of both independent and controlled mines, intended solely for defence of the Dardanelles and certain harbours. All her material had been purchased abroad, and no attempt had been made to develop local resources. None the less, such mines as she did possess were to exercise an important effect on the outcome of the Dardanelles campaign in 1915.

Italy

Italian naval officers had for many years displayed considerable ingenuity in the design of mining material, and there is a possibility that the Japanese minelaying tactics off Port Arthur were based on a study of some exercises carried out by the Italian fleet.

In 1914 the Italians possessed stocks of mines of the following types:

Elia. This type, adopted in a modified form for laying by British minelayers, is described later. Those available to Italy were of an old pattern with inertia firing, those for coast

defence having an explosive charge of 220 lb., while a smaller edition for laying by destroyers carried a charge of 50 lb.

Bollo. This mine, with a charge of 160 lb., was fitted with hydrostatic firing gear similar to the French *Sauter-Harlé* referred to above.

Novero. An old type with inertia firing gear.

Scotti. An unusual type of drifting countermine which sank towards the bottom several hours after laying and fired hydrostatically on reaching a pre-set depth below the surface.

There were also stocks of various old pattern observation mines.

The new light cruisers *Quarto*, *Nino Bixio*, and *Marsala*, together with a number of destroyers and torpedo boats, were equipped to lay mines, and Italy also had the minelayers *Tripoli*, *Goito*, *Partenope*, and *Minerva* of nineteen knots with a load of sixty mines. All battleships and cruisers were arranged to carry four moored mines and eight Scotti countermines.

In view of the above resources, it is somewhat strange that, beyond accepting the mine as a useful weapon, Italy does not appear to have formulated any settled policy for its employment.

The United States of America

In view of the fact that American ingenuity had been largely responsible for the pioneer development in mining technique, it is at first sight somewhat remarkable that the year 1914 found the United States in much the same position as on the conclusion of the Civil War. On closer examination, however, it will be apparent that this state of affairs was in accord with American foreign policy. She did not intend to become embroiled in a Continental war, and she was in any case opposed on ethical grounds to the laying of mines in the open sea. Her mining material was therefore confined to that required for the defence of her principal harbours, it being realized that any attempt to extend this form of protection to her vast coastline would be impracticable.

Other Nations

Nearly all the smaller maritime nations possessed limited of stocks mines for defensive purposes. These were in general

of commercial types, purchased abroad, and not the outcome of native interest or development.

To sum up, the position in 1914 was that Germany had studied the strategical employment of mines, intended to use them without regard to the dictates of humanity, and had accumulated adequate stocks of well-designed material. To a lesser extent, Russia was in the same position, both as regards policy and preparations. Japan, Italy, and France were alive to the potentialities of the mine as a weapon of offence, but such mines as they possessed were not of a highly effective type. Other maritime nations had confined themselves to the provision of mines for defensive purposes only.

It is fair to say that Great Britain was virtually unprepared, but this statement should not be allowed to detract from the value of the work carried out in the preceding forty years in the fleet, in the torpedo schools, and by enthusiastic individuals. To them all praise must be given, but their work had been conducted against a background of vacillating policy, and an adherence to the view that the mine was an underhand weapon of little value to a Power having command of the sea. The argument that in the hands of a weaker Power the mine might be used to redress the balance was dismissed as being an equally good reason for discouraging development.

In short, informed thought on the *employment* of mines, as opposed to their purely technical capabilities, was lacking. There is, however, one fact to be recorded. Work in connexion with underwater weapons and devices had called for a high standard of seamanship and the display of considerable initiative and powers of endurance. The torpedo branch of the Royal Navy had attracted to its ranks a body of officers and men who combined these qualities with a notable measure of intellectual achievement; and so, in spite of the indifference to the value of underwater attack implicit in our pre-1914 policy, they were able to make up the leeway when the time came, while in the sphere of higher command many of them made a brilliant contribution to the Allied cause in two successive world wars.

CHAPTER IV

WORLD WAR I—FIRST PHASE

(From the Outbreak of War to December 1916)

As August 1914 marks the beginning of another distinctive period in the evolution of mine warfare, it would perhaps be useful to summarize here the capabilities and limitations of the material available to various nations at that time:

Independent Mines

(a) *Firing Gear.* Four main types of contact firing gear were in existence:

Chemical (i.e. the Herz horn).
Inertia weight.
Mechanical.
Hydrostatic.

(b) *Depth-taking.* Depth-taking could be effected in three ways:

By plummet } i.e. automatically.
By hydrostat }
By fixed moorings.

The maximum length of mooring rope provided was of the order of 70 fathoms, or 420 feet.

(c) *Explosive Charge.* Explosive charges ranged from 25 lb. of guncotton to about 300 lb. of T.N.T.

Drifting and Oscillating Mines

There was no standard type of drifting mine in existence, but many countries were alive to the possibilities of suspending ordinary contact mines from wooden floats. The only type of oscillating mine was the Leon, but much experimental work had been carried out in this and other countries.

Controlled Mines

Various types of both moored and ground observation mines, as well as electro-contact mines, had been developed.

The use of hydrophones for detecting the approach of enemy ships had also received attention, particularly in Great Britain.

Minelayers

In no country had any ships been designed and built specifically as minelayers, reliance being placed on the adaptation or conversion of merchant ships, small craft, and war vessels, including in some cases submarines.

Countermeasures

Simple wire sweeps for dealing with moored mines had been developed, their effectiveness being increased in some cases by the fitting of explosive charges or grapnels to the sweep wires. Explosive grapnels for 'creeping' against the electric cables of controlled mines were also in existence.

In no country had the self-protection of war vessels in the open sea been considered, but a form of bow-protection gear for mine-sweeping trawlers had been under trial in Great Britain.

Another interesting development, to which no reference has so far been made, and which illustrated the remarkable nature of mine warfare, was in the field of *anti-sweeping* devices. These either took the form of snags designed to prevent the sweep wire from cutting the mine mooring, or evaders designed to allow the sweep wire to *pass through the mine mooring rope* without disclosing the presence of the mine. The most ingenious of the latter type was the sprocket wheel, proposed in 1911 by Assistant-Paymaster C. Bucknell, R.N., and shown in Fig. 17. For various reasons, some ten years were to elapse before this particular device was adopted.

World War I was chiefly remarkable for the development in British mining technique, and for the assistance rendered by the United States of America in 1917-18. It is therefore intended to deal in some detail with these developments, and to relegate a consideration of the activities of other countries to brief notes.

1914

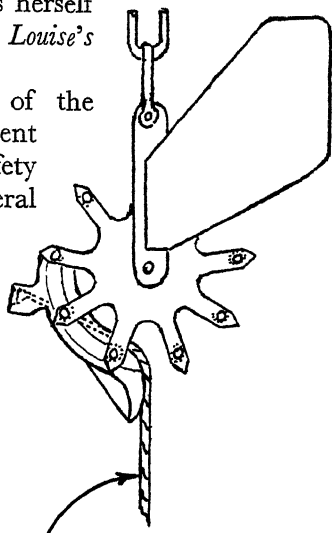
Germany, in accordance with her pre-war policy, was first off the mark, and the minelayer *Koenigen Louise* was well on

her way across the North Sea when war was actually declared. She laid a minefield about 40 miles off Lowestoft on the night of 4/5 August, and on the following day was encountered and sunk by the cruiser *Amphion* and a force of destroyers on their way back from a sweep along the Dutch coast. While returning to base, the *Amphion* was herself mined and sunk on the *Koenigen Louise's* minefield.

The evidence thus provided of the German intention to lay independent mines without regard for the safety of merchant shipping had the general effect of hardening British aversion to this form of warfare rather than of bringing home its possibilities if legitimately used. Proposals were, however, put forward by the Commander-in-Chief, Grand Fleet, to lay mines for the defence of the Straits of Dover against a sortie by German heavy ships.

On the night of 21 August 1914 the German cruisers *Mainz* and *Stuttgart* and the mine-layer *Albatross* laid mines off the Humber and the Tyne. Fortunately, the existence of these fields was discovered almost immediately, and sweeping operations were begun, in the course of which the mine-sweeping gunboat *Speedy* and several trawlers were sunk. In actual fact, these minefields were not well placed from the strategic point of view, as they hampered further offensive operations by German surface forces, and after defining the limits of the dangerous areas it was decided to leave them as part of our own defences. This enabled our available patrols to be disposed to greater advantage, and was the first practical example of this aspect of mine warfare.

By mid-September 1914 the appearance of U-boats in the approaches to the Straits of Dover, coupled with the serious



Mine Mooring Rope

FIG. 17. THE 'SPROCKET WHEEL' SWEEP EVADER

military situation on the Continent, led to pressure being brought to bear on the Admiralty to lay mines as an additional protection for our cross-Channel traffic. The Admiralty remained unwilling as ever to adopt this obnoxious expedient,¹ or to do anything likely to restrict the freedom of movement of the Grand Fleet. The question was therefore referred to the Commander-in-Chief, who, while opposed to any large-scale attempt to lay mines in the Heligoland Bight, still considered it to be desirable to mine the southern part of the North Sea. The Admiralty agreed, and on 3 October a dangerous area was publicly declared in accordance with the Hague Convention. The first operation had been carried out on the previous night, the cruisers *Intrepid*, *Iphigenia*, *Andromache*, and *Apollo* laying mines off Ostende. On the two succeeding nights these four ships laid further minefields off Ostende and to the north-east of the Goodwin Sands, a strenuous performance which was to have its counterpart in much the same area in the early days of World War II.

These operations had been somewhat delayed, and by 4 October the military situation was such that the movement of troopships to and from Zeebrugge had become of vital importance. But the route was blocked by our own minefields, and so a long-suffering Admiralty was forced to sweep a passage through the mines whose laying they had so strenuously opposed. On 16 October, following the evacuation of Zeebrugge, the French minelayers *Pluton* and *Cerberé* laid Breguet type mines off that port, and on 21 October and 1 November they laid further fields off Ostende.

In spite of these hesitant beginnings, a general swing of opinion in favour of minelaying is apparent, for during October 1914 a small minefield was laid to the east of Lowestoft, the first of a number of similar fields to be laid off the coasts of England and Scotland as traps for U-boats operating in focal areas or approaching prominent headlands in order to fix their position.²

¹ *Official History of the Great War (Naval Operations)*, Vol. I, p. 182.

² The areas in which British and American mines were laid in 1914-18 are shown on a map at the end of the book, to which it may be convenient to refer while reading this chapter.

At the same time orders were placed for large numbers of mines. Half of these were to be of the existing naval spherical type, by then known as the 'service' mine, and the remainder of an improved Elia type known as the 'British Elia'. The Elia mine, of Italian origin, had first been examined by us as far back as 1901, and although considered to be of sound design, was expensive and called for an unduly high standard of finish. The British Elia (Fig. 18) differed from the commercial type chiefly in the design of the firing pistol.

It was also decided to reintroduce controlled mining for the permanent defence of certain harbours, including Scapa Flow, and all existing observation and electro-contact material was called in from ports abroad and reconditioned. As this system had been abandoned in 1906 and the material withdrawn from service, it is a little surprising that any remained to be reconditioned, and one may be forgiven for suspecting that a fair amount had been tucked away in various store-houses at the instance of certain far-seeing individuals.

On 27 October 1914 a disaster befell the Grand Fleet which was to bring to a focus the whole British policy with regard to minelaying. H.M.S. *Audacious*, a 23,000-ton battleship commissioned on 21 October 1912, struck a mine off Tory Island in the north-western approaches to the Irish Sea, and, in spite of magnificent work by S.S. *Olympic* and other ships, it proved impossible to save her in the prevailing weather conditions. Exactly twelve hours after being mined, she blew up and sank, the entire

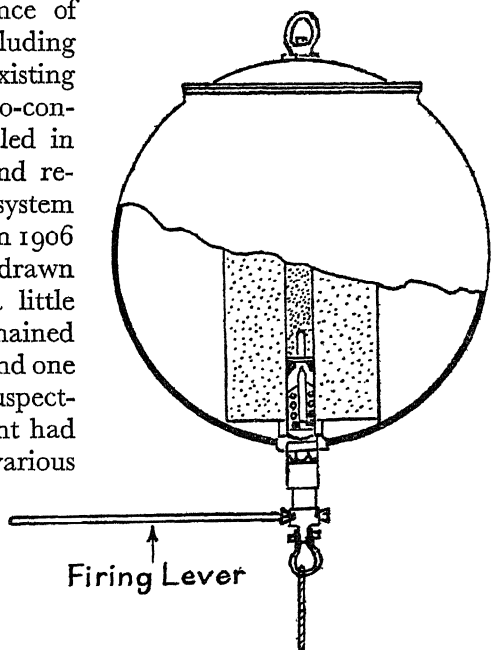


FIG. 18. THE BRITISH 'ELIA' MINE

ship's company having previously been taken off. As a result of this event, the following declaration was issued by the Admiralty on 3 November 1914:

During the last week the Germans have scattered mines indiscriminately in the open sea on the main trade route from America to Liverpool via the north of Ireland. Peaceful merchant ships have already been blown up with loss of life by this agency. The White Star liner *Olympic* escaped disaster by pure good luck. But for the warnings given by British cruisers, other British and neutral merchant and passenger vessels would have been destroyed. These mines can not have been laid by any German ship of war. They have been laid by some merchant vessel flying a neutral flag which has come along the trade route as if for the purpose of peaceful commerce and, while profiting to the full by the immunity enjoyed by neutral merchant vessels, has wantonly and recklessly endangered the lives of all who travel on the sea, regardless of whether they are friend or foe, civilian or military in character.

Minelaying under a neutral flag and reconnaissance conducted by trawlers, hospital ships and neutral vessels are the ordinary features of German naval warfare. In these circumstances, having regard to the great interests entrusted to the British Navy, to the safety of peaceful commerce on the high seas, and to the maintenance within the limits of international law of trade between neutral countries, the Admiralty feel it necessary to adopt exceptional measures appropriate to the novel conditions under which the war is being waged.

They therefore give notice that the whole of the North Sea must be considered a military area. Within this area merchant shipping of all kinds, traders of all countries, fishing craft, and all other vessels will be exposed to the gravest danger from mines which it has been necessary to lay, and from warships searching vigilantly by night and day for suspicious craft. All merchant and fishing vessels of every description are hereby warned of the dangers they encounter by entering this area except in strict accordance with Admiralty directions. Every effort will be made to convey this warning to neutral countries and to vessels on the seas, but from November 5th onwards the Admiralty announce that all ships passing a line drawn from the northern point of the Hebrides through the Faroe Islands to Iceland do so at their own peril.

Ships of all countries wishing to trade to and from Norway, the Baltic, Denmark and Holland are advised to come, if inward

bound, by the English Channel and the Straits of Dover. There they will be given sailing directions which will pass them safely, so far as Great Britain is concerned, up the east coast of England to Farn Island, whence a safe route will, if possible, be given to Lindesnaes Lighthouse. From this point they should turn north or south according to their destination, keeping as near the coast as possible. The converse applies to vessels outward bound. By strict adherence to these routes the commerce of all countries will be able to reach its destination in safety, so far as Great Britain is concerned, but any straying, even for a few miles from the course thus indicated, may be followed by fatal consequences.

There are several points of interest about this declaration. First, it was issued in the name of the Admiralty, whereas its rather far-reaching provisions would seem to have been more appropriate to a pronouncement by H.M. Government. Secondly, and arising from the first point, it was in the nature of a blanket statement covering a large zone, as opposed to a specific definition of areas actually dangerous due to mines. In this respect it went very much further than earlier proposals by the Commander-in-Chief, Grand Fleet. Thirdly, it might be held that the injunction to keep as near the coast as possible indicated an intention to disregard neutral territorial waters. Fourthly, it added a vast number of miles to the passage of a neutral ship proceeding up-Channel to, say, Rotterdam, as a few minutes' work with a chart of the North Sea will show. Fifthly, it imputed the laying of the mines to ships flying a neutral flag, whereas in fact the minefield which accounted for the *Audacious* had been laid by the armed merchant cruiser *Berlin* of 17,000 tons, whose original intention had been to penetrate to the Clyde area. That such a large ship should be able to get as far as she did and return to Germany ranks as a remarkable example of the extent to which the element of chance enters into the conduct of naval warfare.

Finally, it is probable that the *Audacious* struck a mine whose explosive charge did not exceed 160 lb. of guncotton, while both in World War I and World War II there were to be many cases in which quite small vessels were to survive the explosion of 500-lb. charges of T.N.T. It is, in fact, extremely difficult to assess the probable ultimate effect of a charge of given

weight, as so much depends on imponderable factors, such as the state of the weather, the distance of the ship from a base, and the location of the damage.

At the end of 1914 an offer by the Russian Government to supply some of their 1906 type of moored Herz horn mines was accepted. These were converted for use as electro-contact mines and incorporated in the defences of Scapa Flow.

A small number of creeping mines was also produced at the end of 1914, for use in the unidirectional current flowing along the north German and western Danish coasts, but the

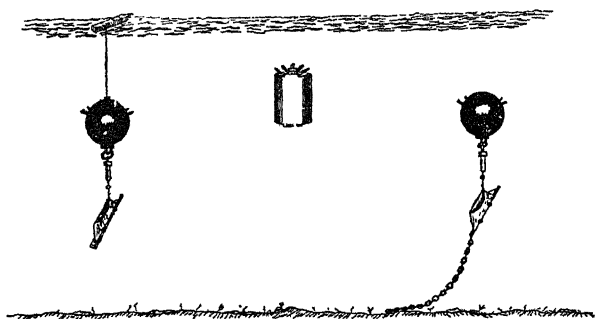


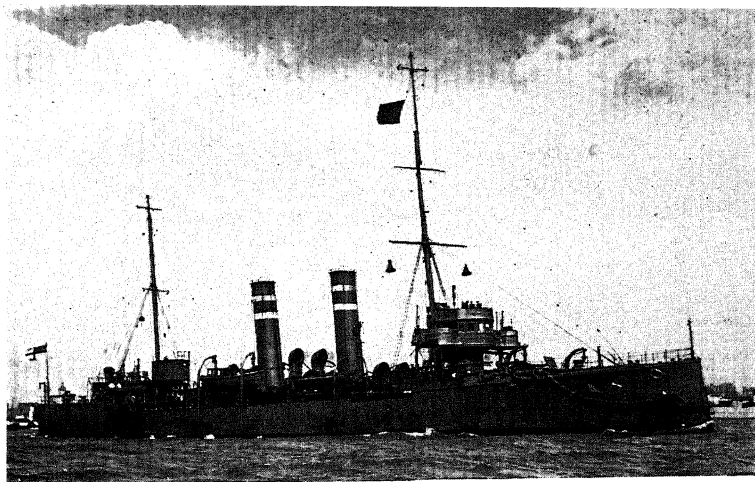
FIG. 19. DRIFTING, OSCILLATING, AND CREEPING MINES

scheme was abandoned as a likely source of danger to our own submarines (Fig. 19).

1915

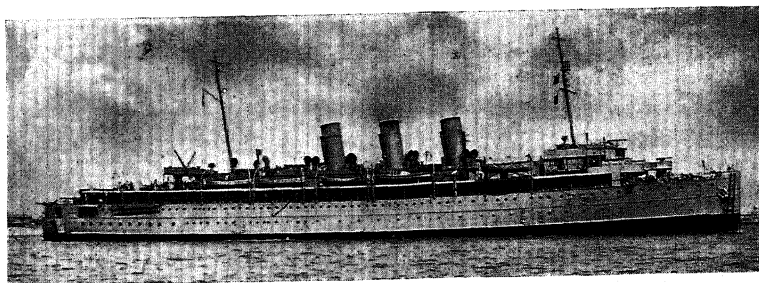
By early 1915 it was clear that we should be committed to an extensive minelaying campaign. Not only were the activities of U-boats causing concern, but the Commander-in-Chief, Grand Fleet, had advocated the laying of mines in the Heligoland Bight as a counter to the movement of German surface forces, and had asked for the supply of oscillating mines to destroyers operating with the fleet. Further orders for Service mines were placed, and also for a small number of oscillating mines of the Leon type, of which Messrs. Beardmore held the British manufacturing rights.

The chief obstacle was the shortage of minelayers. The old converted cruisers of the *Apollo* class were slow and poorly armed, and totally unsuitable for operating in enemy waters.



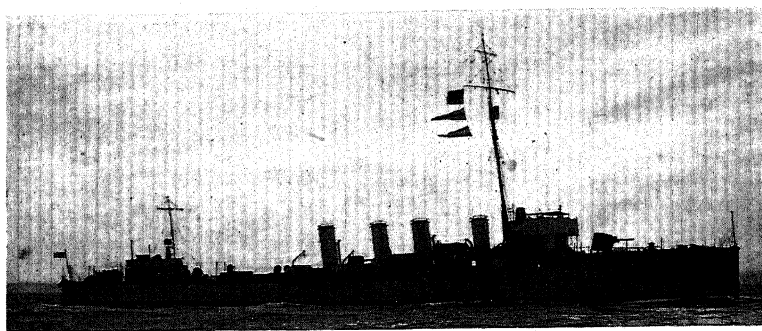
(a) H.M.S. *Latona*

(R. Perkins)



(b) H.M.S. *Princess Margaret*

(R. Perkins)



(c) H.M.S. *Abdiel* (1916)

(R. Perkins)

It was therefore decided to take up and convert the following merchant ships:

S.S. *Paris*. A passenger vessel of 2,030 tons displacement, and a speed of twenty-one knots, normally employed on the Newhaven-Dieppe route. Her chief disadvantage was her small radius of action.

S.S. *Princess Margaret* and S.S. *Princess Irene*. These two 5,440-ton passenger ships, with a speed of twenty-one knots, had just been completed when taken over, being specially designed for the run between Vancouver and Seattle. With their large carrying capacity (500 mines), fair speed, and light draught, they were suitable ships (Plate I (b)).

S.S. *Biarritz*. A 2,700-ton passenger ship with a speed of twenty-one knots, and from the minelaying point of view generally similar to the *Paris*.

S.S. *Orvieto*. A passenger liner of 12,130 tons. Technically very suitable, with a large radius of action and capable of carrying 600 mines ready for laying, with a further 600 stowed below, but operationally she was too slow, presented an enormous target, and drew too much water.

S.S. *Angora*. A combined passenger and cargo ship of 4,298 tons, normally employed on the Calcutta-Rangoon run. She carried 300 mines and had a large radius of action, but was too large and too slow.

Of the above ships, the *Princess Margaret* and *Princess Irene* were originally fitted to carry Elia mines, and the remainder to carry Service mines. A different arrangement of mine rails was required for the two types, a disadvantage from the planning point of view, owing to the reduction in the flexibility of the available minelaying force.

In January 1915, the first British minefield in the Heligoland Bight was laid off the Amrun Bank by the *Apollo*, *Naiad*, *Latona*, and *Iphigenia*. Judged by any standards, it will be agreed that this was an operation of some hazard, the ships being twenty-five years old, armed with four 4·7-inch guns of an obsolescent type, and incapable of exceeding a speed of fifteen knots.

The enemy was soon to achieve another success, for on 18 March 1915, the British battleships *Irresistible* and *Ocean*

and the French battleship *Bouvet* were sunk by mines in the course of the Dardanelles operations, while on 27 May the minelaying force was seriously depleted by the loss of the *Princess Irene*, blown up at Sheerness with the loss of all hands. She was at the time preparing mines for laying, and although the cause of this tragedy was never established with certainty, it was in all probability due to the premature firing of a mine pistol, as the type then in use was capable of being so cocked that a comparatively light jar would release it. Whatever the cause, confidence in this type of pistol was destroyed, and it was fortunate that an improved type was about to be introduced from which the known or suspected defects of the earlier design had been eliminated.

Very little minelaying was carried out during the first half of 1915. After their gallant expedition into the Heligoland Bight in January, the *Apollo* class cruisers had been paid off, and the work of converting the merchant vessels referred to above was still in progress. In addition, difficulty was being experienced in the provision of explosive charges, while many technical defects in the mines themselves and their sinkers were coming to light as a result of laying in the open sea under active service conditions. The first German mine had been recovered in about April 1915, but although its efficiency was appreciated it was decided to adhere to the Service and British Elia types and to improve their design in the light of practical experience.

In May 1915 it was decided to develop an electro-contact *net* mine, proposed by Admiral Sir A. K. Wilson as an anti-submarine measure, and an order for 7,500 of these mines was placed. It was by now evident that the Germans were using submarines for laying mines in British coastal waters with considerable success, and pre-war proposals for the production of a submarine-laid mine were revived. The type first evolved was a moored mine for laying from the torpedo tubes, and the restriction thus imposed on the size and shape prevented a high standard of efficiency being achieved. Later in 1915 it was therefore decided to adapt the submarines E.24 and E.41 to lay twenty mines through vertical tubes in their saddle tanks. This enabled a far more satisfactory design to be

produced, with a diameter of thirty inches. Herz horn firing was incorporated, as it would have been dangerous to fit any form of mechanical firing gear to mines carried externally by a submarine. Depth-taking was by hydrostat and pilot wire. Towards the end of 1915 the production of an oscillating mine was put in hand. The design was based on a principle previously advocated by Lieutenant Sandford, and differed from the Leon type in that the buoyancy of the mine was controlled by the displacement of a disc due to the pressure exerted by a charge of compressed ammonia gas, the latter being in turn controlled by a hydrostatic valve. Two types were evolved, the S.O. for laying by submarines, and the D.O. for laying by surface craft (Fig. 19, p. 50).

In the latter half of 1915, further minefields were laid in the Heligoland Bight, off the east coast of England and Scotland, and in the Channel. The controlled minefields for the defence of harbours were completed. In the Mediterranean, minefields were laid in the Gulf of Smyrna, in the Mandelya Gulf, and in Giova Bay. These operations were carried out by the *Gazelle*, a converted Channel Islands steamer, the French minelayer *Casabianca*, and H.M.S. *Latona*, which had been recommissioned for the purpose.

German activities included the laying of a minefield in the Moray Firth by the *Meteor* on the night of 7/8 August 1915. Disguised as a neutral merchant ship, the *Meteor* was challenged by the *Ramsey*, an armed boarding steamer, whereupon she disclosed her nationality. In the ensuing engagement the *Ramsey*, hopelessly outgunned, was sunk. Four officers and thirty-nine men out of a complement of ninety-seven were picked up by the *Meteor*, who was herself abandoned and sunk by her crew on sighting ships of the Harwich Force while off the Horn's Reef on her return journey. The survivors of the *Ramsey* were saved by a neutral fishing vessel and transferred to one of the British cruisers.

On 9 August the destroyer *Lynx* was mined and sunk in this minefield, and other British losses due to mines in 1915 were the destroyers *Maori* and *Lightning* and the submarines E.6 and C.29 in the North Sea, and the destroyer *Velox* in the English Channel.

1916

In January 1916 the submarines E.34, E.45, E.46, and E.51 were earmarked for fitting as minelayers, and later in the year three more surface craft were converted :

H.M.S. *Abdiel*. A flotilla leader of the *Marksman* class, converted before completion to carry eighty mines. With a speed of about thirty-two knots, she proved most successful and was employed as a minelayer for the rest of the war (Plate I (c)).

S.S. *Wahine*. A passenger ship of 4,630 tons with a speed of about 19 knots, and previously engaged on the New Zealand coastal trade. She had a limited radius of action, and carried rather a small number of mines for her size (180). She replaced the *Orvieta*, the latter having proved to be far too bulky and vulnerable.

S.S. *Perdita*. A small coaster, with a speed of eleven knots, fitted out at Mudros to carry fifty mines ready for laying, with a further fifty stowed below.

The outstanding event of 1916 was the laying of a zareba of mines and mined nets off the Belgian coast between Ostende and the River Scheldt. The ships engaged were the *Princess Margaret*, *Orvieta*, *Biarritz*, and *Paris* and the trawlers *Welbeck*, *Carmania II*, *Osta*, *Shackleton*, *Russell II*, and *Ostrich II*. The operation, which called for the greatest care both in planning and execution, was begun on 24 April 1916 and virtually completed by the end of May. By this date about forty miles of double lines of deep contact mines and fifteen miles of mined nets had been laid at a mean distance of thirteen miles from a strongly defended enemy coast.

The primary purpose of the mined nets was to increase the chances of catching a submerged U-boat. The mines were of the electro-contact type with a charge of 65 lb. (Fig. 20). They were used with some success in various areas, the general practice being to lead the cables to an electric battery housed ashore. In the case of the Belgian coast system, however, the shore was in enemy occupation, and it was therefore necessary to house the batteries in empty mine cases secured to the jackstays which supported the nets. This entailed the periodical servicing of the batteries and testing of the electrical connexions

and insulation, and the author can testify to the fact that this operation, when carried out under fire and in a seaway, is extremely difficult.

The Belgian coast zarefa scored an immediate success,

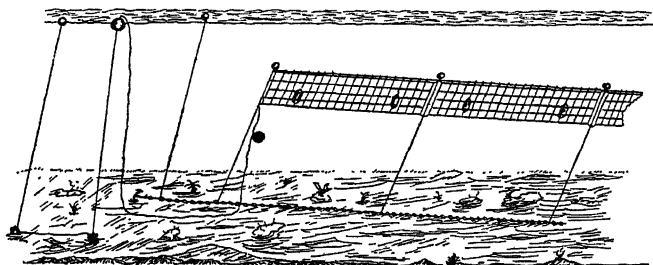


FIG. 20. THE ELECTRO-CONTACT MINED NET

the minelayers having the unusual experience of practically witnessing the destruction of two U-boats.

In the Heligoland Bight, the first British submarine minelaying operation in history was carried out on 7 March 1916 by E.24. During the year the majority of the laying in this area was carried out by *Abdiel* and the minelaying submarines, very few fields being laid by the converted merchant vessels. There were, however, two important technical developments. The first was the provision of taut-wire measuring gear to enable the positions in which minefields were laid to be assessed with greater accuracy, an obvious requirement when carrying out a series of closely related operations. This gear, originally designed for use in ships laying submarine telegraph cables, consisted in simple terms of a long length of piano wire paid out astern of the minelayer, the amount of wire run off being measured with a high degree of accuracy and recorded on a form of cyclometer.

The second development was the provision of sinking plugs for fitting, if required, in mines laid in enemy waters, thereby restricting the effective lives of the minefields. Originally intended to simplify subsequent minesweeping operations, they were now proposed as a means of enabling minelayers to revisit areas already mined for the purpose of reinforcement and also to obviate the fouling of too great an area. Although

subsequently used to a considerable extent in the Heligoland Bight, these plugs were found to be too unreliable in operation to ensure the safety of the minelayers.

In other areas, the laying of mines in the southern part of the North Sea was continued, together with the laying of small deep and shallow anti-U-boat minefields off the coasts of the British Isles. Further minefields were also laid off the approaches to the Dardanelles.

Controlled minefields, already laid for the protection of our principal harbours, were maintained and improved as more material became available. In this latter connexion, the only development of interest was the Magnetophone system, designed to detect the approach of a submarine and so indicate the correct moment at which to fire the mines. It should be noted that this was by no means a new idea, having originally been put forward by Captain McEvoy in 1892.

As a result of trials to establish the causes of various material failures, considerable data had by this time been collected and the design of a mine with Herz horns, a charge of 320 lb. of T.N.T., and anchored by a plummet type sinker had been put in hand by H.M.S. *Vernon*. By December 1916 the Mining School, projected in August of the same year, was functioning in H.M. Gunwharf at Portsmouth, thereby fulfilling a long-felt need for a properly equipped organization charged with the design, trial, and development of mining material.

The year 1916 was also notable for that rare event, the laying of a tactical minefield. On the night of 31 May—1 June the *Abdiel* laid a minefield off the Vyl Lightship in an area through which it was expected that the High Seas Fleet would pass if it attempted to retire via the Horns Reef. In the words of the Commander-in-Chief, Grand Fleet, she carried out this operation unobserved in the same successful manner as numerous other operations had been undertaken by this most useful little vessel. The German battleship *Ostfriesland* was sunk as a result of striking one of these mines, or possibly one in a field laid by *Abdiel* a few weeks previously in the vicinity.

Enemy minelaying activities continued throughout 1916, principally in the shape of small fields laid by U-boats. The

chief British losses were the battleships *King Edward VII* off the north of Scotland in January and *Russell* off Malta in April, and the cruisers *Arethusa* in the North Sea in February and *Hampshire*, with Lord Kitchener on board, off the Orkney Islands in June. The minefield which accounted for the *King Edward VII* was laid by the German raider *Moewe*, disguised as a neutral merchant vessel. She was assisted by the fact that certain coastal lights had to be kept burning for the benefit of the heavy traffic passing through the Pentland Firth.

Since the outbreak of the war, the question of counter-measures had naturally received a great deal of attention. The original flotilla of mine-sweeping gunboats and the trawler reserve had been expanded into an efficient force, a process rendered the more easy by the fact that the material required and the methods of using it were based on those of the fisherman. Adequate though these measures might be for the maintenance of swept channels and the clearing of enemy minefields in coastal waters, neither the gunboats nor the trawlers were capable of accompanying the fleet for the purpose of protecting it while at sea. Various proposals had therefore been made for the fitting of gear designed to be carried by ships themselves for their own protection. After much experiment and trial there emerged the paravane

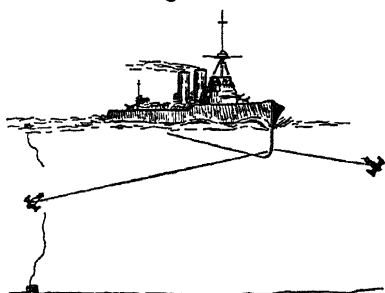


FIG. 21. THE PROTECTOR PARAVANE

(Fig. 21), and by the end of 1916 a number of battleships, battle-cruisers, and cruisers had been equipped. During 1917 the fitting became universal and a modified form was evolved for the protection of merchant ships. In 1917 a suitable form of bow-protection gear was also produced for the minesweeping trawlers, which was in effect simply an improvement on the type tried out in 1913.

CHAPTER V

WORLD WAR I—SECOND PHASE

(From January 1917 to the End of the War)

FROM the beginning of 1917 onwards, British minelaying was on the upgrade. In January of that year the design of the new mine and sinker was accepted and the decision taken to bring our stocks of mines up to the staggering total of *one hundred thousand*, an increase of 2,500 per cent. over the pre-war stocks. The new combination, known as the Mark H.II mine on the Mark VIII sinker, went through the usual teething troubles associated with any new design, but finally emerged as a reliable weapon, stocks of which were still available and were used with success on the outbreak of World War II some twenty-two years later. Other important advances in 1917 were:

(i) The design of an *Acoustic Attachment* for fitting to standard moored mines, and of a *magnetic* firing system for incorporation in a ground mine. Great Britain thus led the world in the development of the non-contact or influence mine.

(ii) The provision of heavy sinkers for laying in strong tides and on bad holding ground (e.g. the Straits of Dover); of hydrostatic safety switches to enable friendly ships to pass over our own deep minefields in safety (i.e. if a mine failed to take up its correct depth it remained safe); and of a method whereby deep minefields could be laid with plummet sinkers. It had previously been necessary to employ fixed moorings for deep minefields.

(iii) The initiation of experiments with the Loop system of detection for use in conjunction with controlled minefields. This system, which it will be more convenient to describe in the next chapter, marked the most important advance in observation mining since its inception some seventy years previously.

With regard to minelayers, it became clear that considerable additions were required to our resources. Owing to the heavy calls on merchant shipping, it would have been impracticable to use vessels of this type, even had any suitable ones been in existence, and the following warships were therefore adapted to lay mines during 1917:

Cruisers. *Ariadne*. This ship was torpedoed on 26 July 1917, off Beachy Head, and was replaced by the *Amphitrite*.

Light cruisers. *Royalist*, *Blanche*, *Aurora*, *Bellona*, *Phaeton*, *Blonde*, *Inconstant*, *Penelope*, *Galatea*, and *Boadicea*. The *Courageous* was also fitted to lay mines, but was never so employed.

Destroyers. *Tarpon*, *Legion*, *Telemachus*, *Ferret*, *Vanoc*, *Ariel*, *Vanquisher*, *Vehement*, *Venturous*, *Meteor*, *Venetia*, and *Vivacious*.

Motor launches. Twelve of these craft were fitted in England and two in the Mediterranean, together with the lighter X.149.

Coastal motor boats. Twenty-one C.M.Bs. were fitted to lay from one to three mines, according to the type of boat.

The principal minelaying effort in 1917 was in the Heligoland Bight. It had not originally been intended to lay any minefields outside a radius of fifty miles from the island of Heligoland itself, and by the end of 1916 some 6,000 mines had been laid, of which about 600 had been fitted with sinking plugs. Accurate information was not, however, available as to the extent to which these minefields had been cleared by the enemy, and sufficient reliance could not be placed on the sinking plugs to allow the minelayers to revisit the areas in which they had been used. In January 1917 Sir David Beatty, who had relieved Sir John Jellicoe as Commander-in-Chief, Grand Fleet, put forward proposals for laying a complete barrage of both shallow and deep mines across the entrance to the Bight. The front to be covered, about 160 miles, would have involved the laying of 60,000 mines, which at that time were not available. Rather than await the accumulation of the necessary stocks of mines, it

was decided to continue the laying of small independent fields as the mines came forward from production, and so build up a fresh system outside that previously mined.

It will be recalled that in November 1914 the Admiralty had declared the whole of the North Sea to be a military zone in which mines might be laid without further warning, but it was nevertheless deemed wise to issue a formal notice of the area now to be mined. The limits of the area were extended from time to time as the operations progressed, and, following protests by Denmark and Holland, some modification was subsequently made in order to exclude the territorial waters of these two countries. The Dutch Government eventually established four lightships to mark the western limits of the declared area for the benefit of neutral traffic proceeding from north to south. These lightships were of equal benefit as points of departure for our minelayers entering the Bight.

The fields were laid by the following ships: *Princess Margaret*, *Wahine*, *Angora*, *Ariadne*, *Bellona*, *Royalist*, *Phaeton*, *Blanche*, *Inconstant*, *Galatea*, *Abdiel*, *Tarpon*, *Telemachus*, E.45, E.46, E.51, E.34, and E.41. (The first of the submarine minelayers, E.24, had been lost in March 1916 after carrying out one operation.)

The first of the new H.II mines were laid in the Bight on 24 September 1917.

In the Dover area, the laying of a barrage of mines and nets from the South Goodwin shoal to the Snouw Bank (off Dunkirk) had been started at the end of 1916, and this was completed in February 1917. The mined nets were secured to buoys laid 500 yards apart, backed up by three lines of deep mines.

Off the Belgian coast, a line of mined nets was run to seaward of the zareba laid in 1916, while further inshore the coastal motor boats did excellent work in the laying of small fields off Zeebrugge. The mines laid by these craft were similar to those laid by the submarines, being slid horizontally from the torpedo troughs (Plate II).

In our own waters a series of deep anti-U-boat minefields was laid in the Channel and further deep and shallow fields were laid off the East Coast and in the Thames Estuary. The latter fields, which formed part of an extensive scheme of

local defence, were laid by the converted motor launches and the lighter X.149, based on Sheerness.

Operations in the Mediterranean included the laying of further minefields off the Dardanelles, Aivali Bay, and Cape Otranto by the *Biarritz*, the *Perdita*, and two motor launches.

The proceedings outlined above did not denote any change in policy, but rather an extension of the existing policy. By early 1917, however, it had become evident that drastic anti-U-boat measures were required if an Allied defeat was to be averted. In theory, the most effective counter to the U-boats would have been to prevent them from leaving harbour at all, and consideration was in fact given to proposals for the physical blocking of the U-boat bases. These schemes, except in the case of Zeebrugge, were held to be impracticable and attention was therefore directed to the use of minefields for the interception of U-boats while on passage to their operational areas, or in the then current but extremely misleading phrase, the 'sealing of the North Sea'. These deliberations resulted in the planning and execution of two major minelaying operations, the Northern Barrage and the Folkestone-Gris Nez Barrage, which will be dealt with separately.

With the exception of the armed merchant cruiser *Laurentic*, no British heavy ships were sunk by enemy mines in 1917, but a heavy toll was taken of our light forces. The destroyers *Ghurka*, *Foyle*, *Laforey*, *Myrmidon*, *Derwent*, *Cheerful*, *Recruit*, *Surprise*, *Tornado* and *Torrent*, the sloops *Mignonette* and *Alyssum*, the submarine E.49, the patrol boat P.26, and the mine-sweeping gunboat *Jason* were all sunk in home waters or the North Sea, and the destroyer *Attack* and the sloop *Aster* were sunk in the Mediterranean.

The German raider *Wolf* also created a considerable disturbance in the course of a four and a half months cruise by laying small minefields off Saldanha Bay, Cape Agulhas, Aden, Colombo, Bombay, and Singapore, and in Australian waters.

Correspondingly heavy casualties were inflicted on the enemy as a result of our continued minelaying in the Heligoland Bight and the introduction of the more effective H.II mines. The morale of the German minesweeping forces was

beginning to falter, and from the winter of 1917-18 onwards they attempted to do no more than try and keep certain routes open, leaving the rest of the area unswept.

The Northern Barrage

The most cursory glance at a chart of the North Sea (Fig. 22) will show that the establishment of a mine barrage presented two major difficulties. First, the selection of a suitable line for the barrage, and, secondly, the number of mines required, which would be enormous whatever line was chosen.

It would be tedious to enumerate in full the various proposals which, beginning in July 1917, were examined and abandoned before the final position and make-up of the barrage was decided, but the following salient points emerged:

A line across the centre of the Heligoland Bight from the Frisian Islands to the Danish Coast would be footed in neutral waters at each end, leaving gaps through which the U-boats could pass. It would leave the Kattegat open and would need to be heavily patrolled to prevent the operation of German minesweepers (Line X in Fig. 22).

A line running from the French or Belgian coasts up through the North Sea and then eastward to the coast of Jutland would be far too long, and even with lighted and defended gaps would unduly restrict the movements of British forces in the North Sea. It would also leave the Kattegat uncovered. (Line Y in Fig. 22.)

A line running from the north-east coast of Scotland to the Shetland Islands and thence eastwards towards the Norwegian coast would be impracticable on account of the strong tides and bad holding ground in the vicinity of the Pentland Firth and the Fair Island Channel. With the mines then available the barrage could not have been laid to within less than about forty miles from the Norwegian coast, owing to the depth of water. (Line Z in Fig. 22.)

It was however confidently expected that this latter difficulty would shortly be overcome, which in fact it was, and the line Aberdeen-Egersund was provisionally selected for the following reasons:

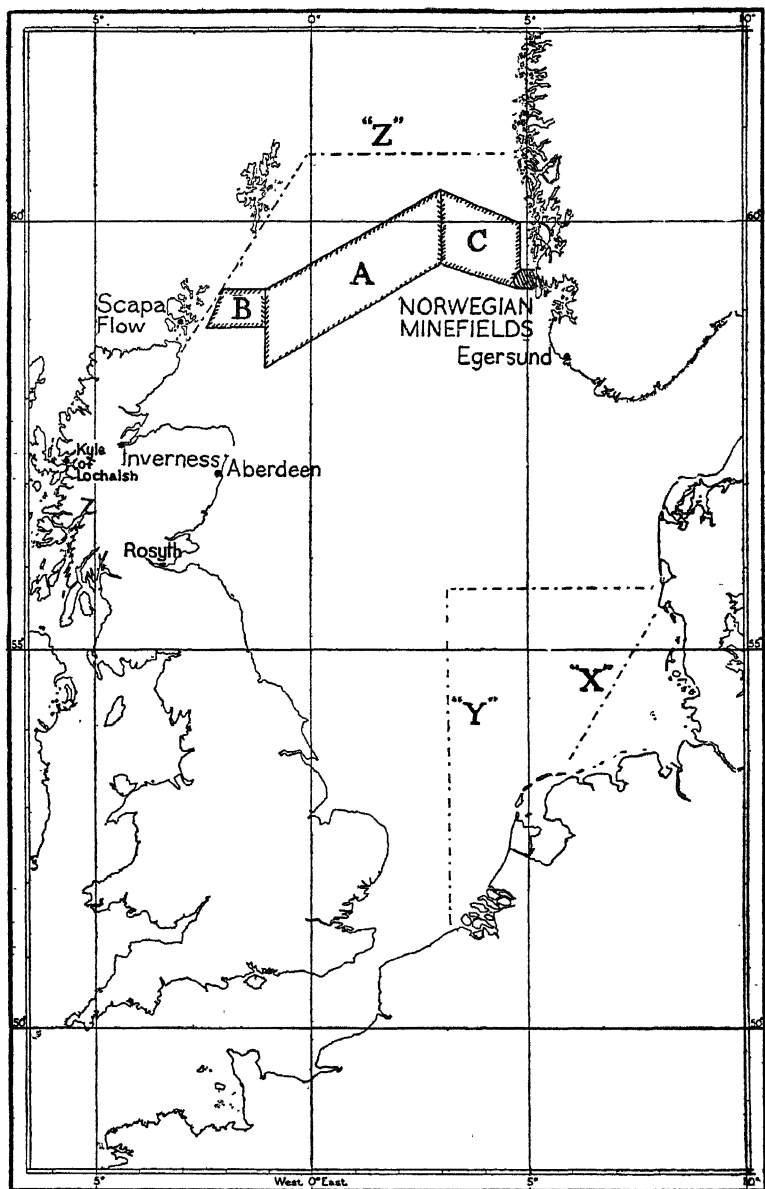


FIG. 22. THE NORTHERN BARRAGE, 1918

(a) The distance from enemy ports would render mine-sweeping impracticable unless supported by heavy ships, in which case the High Seas Fleet might be brought to action under conditions favourable to ourselves.

(b) The line was shorter than any other hitherto considered.

(c) The Grand Fleet, if based on Rosyth, would be on the correct or enemy side of the barrage.

(d) U-boats damaged in the barrage would be vulnerable to attack during the long passage home.

(e) The eastern end of the line would be easier to guard, whether or not Norway entered the war.

(f) The Kattegat would be covered.

At this time, the intention was to use the new British H.II mine, but the numbers required would have been beyond the manufacturing or laying capacity of this country, and it was proposed to accept the assistance offered by the United States of America, who had entered the war in April 1917. At an Allied Naval Conference held in London in September, these proposals were agreed in principle and later in the month the formal concurrence of the United States was received.

The original intention was to declare only the centre portion of the barrage as being dangerous and to mine this area with shallow as well as deep mines. The wing areas were to be traps mined with deep mines only, their existence being kept secret. The main object was to reduce the area to be watched by mobile anti-submarine forces; and at the time great faith was placed in the development of a satisfactory hydrophone for locating U-boats and in the possible establishment of a base for patrol craft in Norway. The British minelayers were to be based in the Firth of Forth and the American minelayers in the Inverness and Cromarty Firths.

Further examination of these proposals by the Commander-in-Chief, Grand Fleet, in November showed them to require drastic revision. The chief drawback to the original plan was the impossibility of maintaining adequate patrols over the eastern wing of the barrage in the absence of a base in Norway, and it was by then evident that such a base would not become

available. Secondly, the movements of the Grand Fleet would still be unduly restricted. It was therefore decided to change the general line of the barrage to run between the Orkneys and Norway, a distance of some 240 miles. The advantages and disadvantages of this line, as compared with the Aberdeen-Egersund proposals, were:

(a) The Grand Fleet was less restricted, and would not be forced to remain based on Rosyth.

(b) The line was shorter, patrols in the eastern area would be even further removed from interference by the enemy, and damaged U-boats would have still further to go to reach their home ports. Against this the British mine-layers would have nearly twice as far to go from their base in the Firth of Forth and the weather for patrol craft would be rather less suitable.

(c) There would on balance be less interference with fishing interests.

(d) Although the Pentland Firth was not covered, it was considered that the transit of this area by submerged U-boats was impracticable owing to the strong tides.

This new line was agreed, but in the meanwhile there had been important technical developments. From the moment of the entry of America into the war, the American Bureau of Naval Ordnance had been impressed with the possibilities of such a barrage and had put forward various proposals. In particular, attention had been directed to the need for reducing the number of mines required, and since June 1917 work had been in progress on a new method of actuation. In September a British torpedo officer (Lieutenant R. H. De Salis) had been sent to America with the difficult task of advising the Board of Admiralty on this new system. He reported that, although still in the trial stage, in his opinion the design possessed sufficient merit to warrant adoption. By December the Americans were in a position to guarantee production in quantity and the risks inherent in the elimination of full-scale trials were accepted.

Thus was born the antenna mine. The principle, an extremely simple one, depended on the sea-cell set up between the hull

of a steel ship and a copper element in the mine, the surrounding salt water acting as the electrolyte (Fig. 23).

Although simple in theory, it will be appreciated that the antenna system depends on a high standard of insulation if the mine is to be prevented from firing prematurely due to

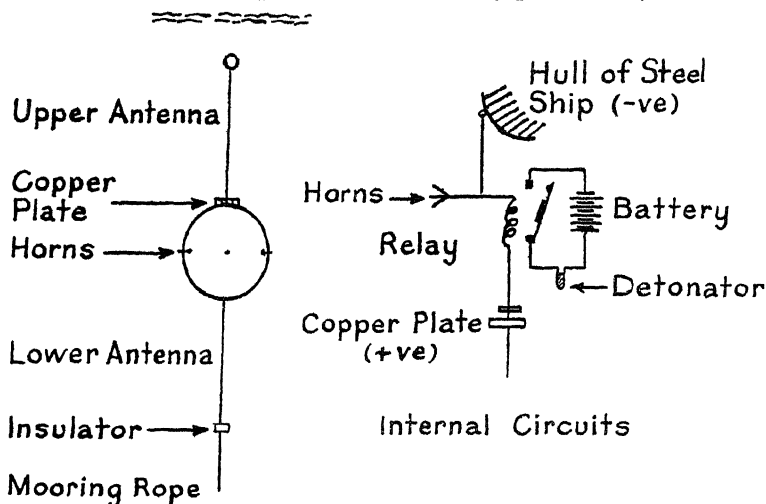


FIG. 23. THE ANTENNA MINE

stray currents set up between its own steel and copper components. Moreover, as subsequent peacetime trials were to show, a very firm contact between the antenna and the hull of a U-boat is necessary to produce sufficient current to actuate the firing mechanism. Finally, the endurance of the upper antenna is not high.

None the less, the mine had the advantage of covering a greater distance in the vertical plane than the simple contact mine, while still producing an explosion within lethal range of a U-boat. As originally produced, the American mine had a vertical danger space of 140 feet, thereby doing the work of about four contact mines. This great saving in material and laying time was the governing factor in reaching a decision.

In January 1918 the plan was generally agreed. The centre area ('A' in Fig. 22, p. 63) was to be mined by the Americans with antenna mines, and the wing areas 'B' and 'C' by the British with H.II contact mines. Mine depots for the former

were to be set up in the Dalmore Distillery at Alness, near Invergordon, and in the Glen Albyn Distillery at Inverness, the mines after crossing the Atlantic being transported by rail from Kyle of Loch Alsh on the west coast of Scotland or by lighter through the Caledonian Canal from Corpach. For handling British mines, the existing facilities at Grangemouth in the Firth of Forth were to be extended, and a Rear-Admiral (M.) had been appointed in October 1917, with his headquarters at that base.

Various delays occurred in the establishment of the American bases and also in the arrival of their minelayers, while the British mines and minelayers were not available until 2 March 1918. On that date the first deep mines were laid in the western area 'B' by the *Paris*, further mines being laid by the *Princess Margaret*, *Angora*, and *Wahine*. These mines were fitted with the deep switches to render them safe at any less depth than 48 feet. On 22 May 1918, the sloop *Gaillardia* was sunk by a mine in this area, and although as far as the author is aware it was never definitely established that this was a British mine, a skimming sweep was carried out and many mines were found to be shallower than the set depth. The mines already laid in this area were therefore swept up and operations temporarily suspended.

In the meanwhile, it had been decided to abandon the elaborate system of patrols, partly due to the hydrophone detector having failed to come up to expectations and partly due to the impossibility of sparing the large number of patrol craft required. As a corollary, it had been agreed that area 'C' as well as area 'A' should be mined with both shallow and deep mines. This change of plan was in any case favoured by the American authorities, who had from the outset recommended that the whole barrage should be made dangerous from the surface to as great a depth as possible.

On 30 April 1918, the battleship *London* and the cruiser *Amphitrite*, both converted for minelaying, proceeded to Grangemouth to replace the *Paris* and the *Wahine*, neither of whom had sufficient endurance to be operated in the eastern area 'C' with an adequate margin of safety.

On 26 May 1918, the American minelaying squadron

assembled at Cromarty under Rear-Admiral Joseph Strauss, U.S.N., who had arrived in the United Kingdom in February to take up the appointment of Commander Mine Force, United States Atlantic Fleet.

The American squadron comprised the following ships:

<i>San Francisco</i>	.	.	170 mines	} Converted cruisers
<i>Baltimore</i>	.	.	180 "	
<i>Roanoke</i>	.	.	830 "	
<i>Canandaigua</i>	.	.	830 "	
<i>Canonicus</i>	.	.	830 "	} Converted merchant vessels
<i>Housatonic</i>	.	.	830 "	
<i>Quinnebaug</i>	.	.	614 "	
<i>Saranac</i>	.	.	580 "	
<i>Shawmut</i>	.	.	320 "	
<i>Aroostook</i>	.	.	350 "	
Total . . .			5,534 "	

On 27 April 1918, the following Notice to Mariners was issued by the Admiralty:

In view of the unrestricted warfare carried on by Germany at sea by means of mines and submarines, not only against Allied Powers, but also against neutral shipping, and the fact that merchant ships are constantly sunk without regard to the ultimate safety of their crews, H.M. Government gives notice that on and after 15th May, 1918, the following area will be established in the North Sea dangerous to all shipping, and should be avoided:

The area enclosed by a line joining the following positions:

- (1) $59^{\circ} 12\frac{1}{2}'$ N. $4^{\circ} 49'$ E.
- (2) $59^{\circ} 29'$ N. $3^{\circ} 10'$ E.
- (3) $58^{\circ} 25'$ N. $0^{\circ} 50'$ W.
- (4) $59^{\circ} 20'$ N. $0^{\circ} 50'$ W.
- (5) $60^{\circ} 21'$ N. $3^{\circ} 10'$ E.
- (6) $60^{\circ} 00'$ N. $4^{\circ} 54\frac{3}{4}'$ E.

thence along the western limits of Norwegian territorial waters to position (1).

It will be seen that only areas 'A' and 'C' were covered by this notice. Area 'B', at that time planned to contain deep

mines only, was not mentioned. Various light buoys were also laid to mark the limits of the area and to serve as accurate points of departure for the minelayers when laying the various sections of the barrage.

Laying operations began in areas 'A' and 'C' on 8 June 1918. Severe premature firing and countermining troubles were experienced with the American mines, and although considerable improvement was effected in due course this defect was never completely eradicated. To a lesser extent, the British H.II mines tended to countermine, and this was met by laying them in groups of four with the mines in each group spaced at the standard interval of 120 feet, but with the distance between the groups extended to 150 feet.

It is not intended to describe the operations in detail, but simply to note the changes in policy which occurred from time to time as the barrage took shape. At the start, it had been found necessary to abandon the idea of fitting a lower antenna to the American mines, and in July 1918 it was agreed that the upper antennae of the shallow mines should be reduced in length to 35 feet. As the mines were laid with the antenna float 10 feet below the surface, this brought the mines themselves to a depth of 45 feet instead of 80 feet. The decision followed British representations that disablement of a surfaced U-boat would probably not be achieved if the explosion of the mine took place more than 30 feet beneath the hull.

By August 1918 it had become fairly clearly established that the U-boats were avoiding areas 'A' and 'C' and were proceeding either across area 'B' or through Norwegian territorial waters. It was therefore decided to lay shallow as well as deep mines in area 'B', but to refrain from declaring the area as dangerous, a ten-mile gap being left to the eastward of the Orkneys for use by the Grand Fleet in emergency.¹ Following on numerous Allied representations, the Norwegian Government was eventually persuaded that patrols alone were incapable of preserving the integrity of her territorial waters, and on 29 September 1918, they published a notice in the following terms:

¹ No danger arose to Allied or neutral shipping, all of which was in convoy, and this decision was not therefore contrary to international law.

: Commanding Admiral yesterday issued notice that automatic contact mines will be laid in Norwegian waters between 59 deg. 6 min. North and 59 deg. 25 min. North Latitude and east of 5 deg. 10 min. East Longitude.

The waters above mentioned will, therefore, be closed for general traffic from Monday, October 7th, next. (*Vide* Fig. 22, p. 63.)

On 8 October 1917 a similar Notice to Mariners was issued by the Admiralty. The effectiveness of the Norwegian mines could not be judged, but it was generally considered that U-boats would be deterred from passing through the area declared to be mined. The desire of the American authorities to establish the barrage from coast to coast was thus fulfilled, with the exception of the ten-mile gap off the Orkneys, and they continued to press for this gap to be filled. The Admiralty, however, found themselves unable to agree to any further restriction being imposed on the movement of the Grand Fleet unless and until it was clearly established that U-boats had discovered and were using this passage.

The last operation was completed on 26 October 1918, bad weather and low visibility between that date and the cessation of hostilities preventing any further laying.

In the space of five months the ten American minelayers had laid no less than 56,033 mines and the four British minelayers had laid 15,093, including 1,360 swept up in area 'B' after the mining of the *Gaillardia*.

The foregoing brief account does no more than outline some of the factors to be considered in a major undertaking of this sort, but it will be apparent that the production, transport, storage, and preparation involved in the laying of groups of over 5,000 mines at frequent intervals called for an organization of the highest calibre, to say nothing of the problems to be faced in the accurate placing of the minefields, the provision of escort and supporting forces for the minelayers, and the vagaries of the weather.

The Northern Barrage was credited with the destruction of a small number of U-boats, and with damage to others. Whether the effort expended was justified by the results achieved has been the subject of debate, and in the years immediately succeeding the war there was perhaps a tendency

in American political circles to assess the effectiveness of the scheme solely in terms of its magnitude and the speed with which it was executed. Thus Mr. Josephus Daniels, the American Secretary of the Navy, wrote:

This marked the end of that enterprise which 'shut up the hornets in their nests'—that bold adventure which was the greatest new naval offensive of the war.

It is unquestionable that the American contribution to the project was eloquent of their characteristic drive and ingenuity, and it must also be remembered that they were in a position to make that contribution without great detriment to their war effort as a whole. If, in addition, account be taken of the potential saving in Allied tonnage represented by the destruction of even one U-boat, it becomes evident that the laying of the Northern Barrage was a worthwhile undertaking *in the circumstances prevailing at the time*.

From the point of view of the student of mine warfare, it is, however, of some importance to evaluate the practical effectiveness of the barrage as such, and sufficient time has now elapsed to enable a dispassionate view to be taken of the matter.

The mathematical considerations affecting the number of mines required to achieve a given probability of success under various conditions are dealt with in Appendix I to this book, and it will be sufficient to note here that *in theory* a submerged U-boat had two chances in three of getting through the barrage, while at periscope depth she would have had one chance in three.

These figures, however, referred to the minefields *as planned*, and assumed the complete technical efficiency of the mines themselves. In the event, the actual chances of a U-boat getting through were considerably greater. In the first place, the barrage was not laid as rapidly as intended, and, secondly, the effectiveness of the mines themselves was reduced by the necessity to abandon the fitting of the lower antennae and the losses due to premature firing. Furthermore, as already noted, subsequent trials were to show that unless a good metal-to-metal contact was made between the antenna and the hull of

a U-boat the mine might fail to fire. Put the other way, a U-Boat could encounter a mine and sustain no damage. Finally, adequate patrol forces could not be made available to take advantage of the presence of the minefields.

Some of the practical limitations were thus attributable to factors lying outside the control of the Americans, some were attributable to the haste with which the mines were designed and produced, and some were inherent in the antenna system itself. It is believed that officers of the United States Navy share with their predecessors of World War I an awareness of these considerations, which are typical of the cold, hard facts to be appreciated before embarking on an undertaking of this nature.

While, therefore, it is only plain justice to our Allies to record that the laying of the Northern Barrage made a contribution to the defeat of Germany, it would be correspondingly unfair both to them and to posterity to regard the minefields themselves as capable of 'sealing the North Sea'.

The Folkestone-Gris Nez Barrage

As we have seen, the Belgian coast zarefa had scored an immediate success when first laid in April 1916. The reinforcement of this system by a line of mined nets in July 1917 had, moreover, coincided with a temporary lull in U-boat activity, and it is believed that these two events resulted in rather too much confidence being placed in this type of obstruction. In consequence, the mined nets completed in January 1917 between the Goodwin Sands and the Snouw Bank were renewed. It was, however, recognized by the Vice-Admiral, Dover, that the greater depth of water and the stronger tides in this area produced conditions which were considerably less favourable than those off the Belgian coast, and early in May 1917 he advocated the laying of deep minefields between Cape Gris Nez and the Varne Shoal (Fig. 24).

In June 1917 a conference was held at the Admiralty at which it was alternatively proposed to site the deep minefields between Beachy Head and St. Martin. Although the distance to be covered was greater, the depth of water was approximately the same as on the Folkestone-Gris Nez line, while

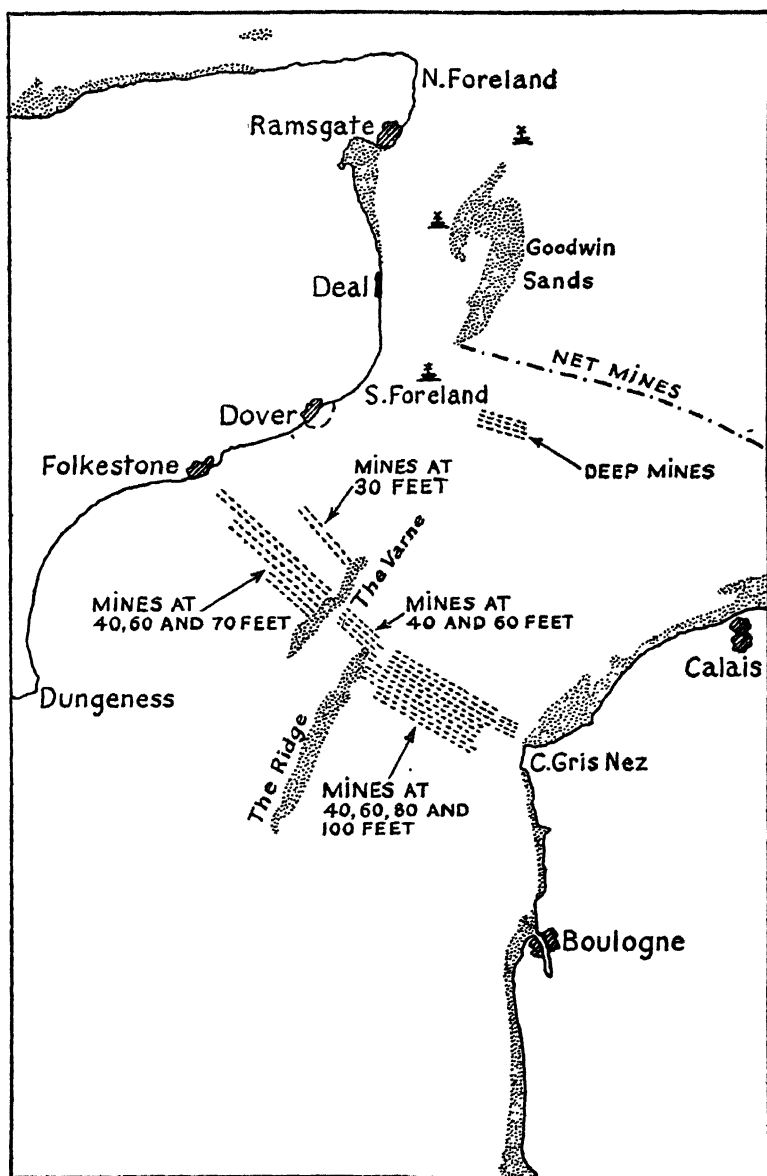


FIG. 24. THE FOLKESTONE-GRIS NEZ BARRAGE, 1918

the tide ran at under one knot as compared with three knots or more. The Vice-Admiral raised very strong objections to this scheme, particularly with regard to the increased number of mines required. He also pointed out that the Gris Nez-Varne passage was the natural deep-water gut through which the majority of the U-boats passed, and that deep minefields laid with secrecy in this area would have every chance of success. As a new type of heavy sinker had been developed to meet the severe tidal conditions, the Gris Nez-Varne area was chosen and all preparations made to begin laying as soon as possible.

In November, 1917, a Channel Barrage Committee was formed at the Admiralty under a Rear-Admiral for the purpose of investigating and reporting on the possible measures for constructing a barrage across the Channel between England and France. The Vice-Admiral, Dover, while conceding the necessity to seek the best advice on the technical and engineering aspects of the problem, took considerable umbrage at the implied centralization of control, which after the war he described as 'dabbling by a committee who had no local knowledge, experience, or responsibility'.¹ The crux of the matter really lay in the disposition of the local patrol forces rather than in the location and nature of the barrage itself. The latter was without question a matter for centralized direction if the best use was to be made of the national resources, while the management of the patrols was one for mutual co-ordination between the Admiralty and the responsible flag officer. We are here concerned with the laying of the barrage, and it would ill become the writer to comment further on what appears to have been a matter of personalities rather than of principles.

Operations in the Gris Nez-Varne area were begun on 21 November 1917 by the *Amphitrite*, *Paris*, and *Princess Margaret*, and continued by these ships and the trawlers *Osta*, *Carmania II*, and *Ostrich II*, and the destroyers *Ferret*, *Legion*, *Ariel* and *Meteor*.

At the same time, the Vice-Admiral, Dover, proposed that the deep minefields be extended to cover the area between

¹ *The Dover Patrol, 1915-1917*, by Admiral Sir Reginald Bacon (1920).

the Varne Shoal and Folkestone, that searchlights with both fixed and wandering beams be established at Folkestone and Gris Nez, and that three or more vessels equipped with guns and searchlights be moored at intervals across the Channel. He further recommended that two lines of shallow mines should be laid 8 feet below low water right across the Channel from a position one mile south-east of the gate in the barrage off Folkestone to a position two miles north-west of Gris Nez. These proposals were approved, with the exception of the laying of the shallow mines, thereby raising a point on which opinions were sharply divided.

Those in favour of the shallow mines held that they would obstruct the passage of U-boats on the surface, would deter them from laying shallow mines in our own minefields, and would enable the patrols to be effectively distributed without danger to themselves. The opposite school of thought put their faith in deep minefields, with complete freedom of movement for the patrols, whose effectiveness all round the clock could be maintained by so illuminating the area as to turn night into day. On technical grounds alone, the adequately patrolled and illuminated deep minefield is considered to have offered the correct solution. Owing to the rise of the tide and the dip of the shallow mines due to the strong local currents, subjects dealt with in more detail in the next chapter, they would have spent much of the time at a depth sufficient to give ample room for the safe passage of U-boats in surface trim, while still remaining dangerous to our own hunting forces.

This problem of dealing with the surfaced U-boat in tidal waters had called forth many ingenious proposals. One of these, the 'E.C. Attachment' devised by Admiral of the Fleet Sir Arthur Wilson, had been subjected to extensive trial, but found to be ineffective, and no others showed any promise (Fig. 25).

The possibility of enemy minelaying in the area would undoubtedly have given the minesweepers a difficult but by no means impossible task. To be effective against our own surface craft, the enemy shallow mines would by definition have had to be laid much nearer to the surface than our own

deep mines, and their disposal would simply have been a matter for careful adjustment of the depth of the sweeps. As a last resort, both our own and the enemy mines could have been swept up together, and as the latter could only be laid

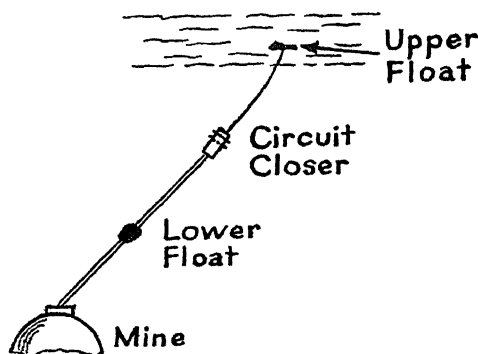


FIG. 25. THE 'E.C.' ATTACHMENT

by submarines in small fields the effect would not have been serious.

In addition to the laying and illumination of the deep minefields, the Channel Barrage Committee recommended the following measures:

(a) The laying of an explosive obstruction about one and a half miles to the eastward of the deep minefield. This idea, known as the S.M. scheme, was found to be impracticable and eventually abandoned (Fig. 26).

(b) The laying of controlled minefields on the new 'loop' system, to which reference has already been made, to cover the gaps between the shore and the gates in the barrage off Folkestone and Gris Nez. This was done.

(c) In place of the old Cross-Channel Barrage between the Goodwins and Dunkirk, the laying of ground magnetic mines in the shallower water and of moored acoustic mines in the deeper water. This proposal showed an admirable grasp of the problem to be faced in the difficult local conditions. The ground magnetic mines would have been immune from dragging in the strong tides, while the non-contact properties of the moored acoustic mines would have had a

chance of being effective against U-boats which might otherwise have passed in safety over moored contact mines which had 'dipped'. Unfortunately, the production of magnetic and acoustic mines had not then got into its

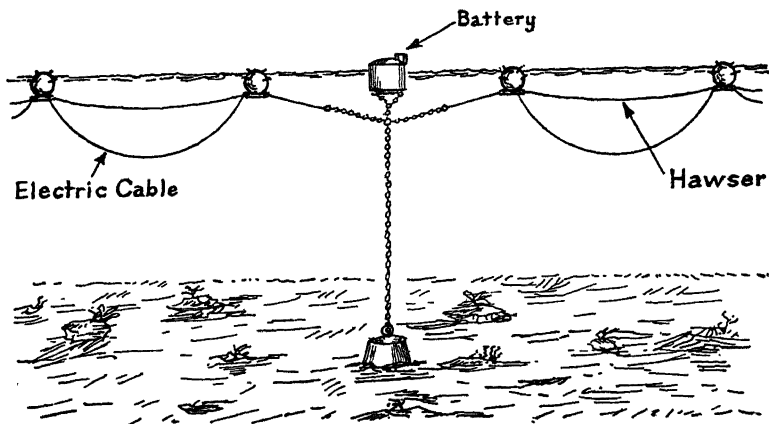


FIG. 26. THE 'S.M.' SCHEME

stride, and instead a triple line of shallow H.II moored contact mines was laid.

Laying in the Folkestone-Gris Nez area proceeded steadily in accordance with the approved plan, the trawlers *Russell II*, *Norman*, *Hero*, *Pitfour*, *Kate Lewis*, *Savitri*, and *Strathcoe* being added to the minelaying force, from which the *Princess Margaret* was withdrawn in January 1918 for operations in the Northern Barrage.

For a variety of technical reasons, automatic depth-taking of the plummet type could not be used with the special heavy sinkers produced for laying in this area, and the hydrostatic system was not suited to the tidal conditions. The two types of sinker produced, the Mark XI and the Mark XII, were therefore fitted with adjustable fixed moorings. In this system, the length of mooring required is set on a nut which travels along a threaded rod. The mine and sinker go to the bottom together, and the melting of a soluble plug releases the mine, which then rises towards the surface. The revolution of the mooring rope drum causes the nut to travel along the threaded

rod for a distance determined by the original setting, and when this distance has been run off the nut takes up against a stop which prevents further movement and so locks the drum.

The use of these fixed moorings involved the survey and buoyage of the area, and two different types of mine were used, the new standard H.II and a smaller edition known as the H.IV. The latter contained an explosive charge of 150 lb. of amatol, considered more than adequate to ensure the destruction of a U-boat.

The operation was virtually completed by August 1918, a total of nearly 10,000 mines having been laid. Certain countermining difficulties had arisen, due chiefly to defects in the manufacture of the glass tubes for the Herz horns. This had necessitated some readjustment in the spacing of the mines and the sweeping and relaying of several of the lines. Five armed vessels, with searchlights and hydrophones, had been moored on each side of the deep minefields and by night the whole area was illuminated by flare-burning patrol craft in addition to the searchlights. The whole layout is shown on Fig. 24, p. 73.

In all, ten U-boats were destroyed in the Folkestone-Gris Nez deep fields, and the controlled minefield off Folkestone accounted for one more. In the light of these successes, it seems pertinent to ask why the enemy was not deterred altogether from attempting to pass U-boats through the Straits of Dover. In the first place, the situation in Germany was becoming desperate, and the shorter route from Ostende and Zeebrugge to the fruitful areas in the Atlantic and the western approaches presumably had its appeal. Secondly, the percentage of kills to successful passages may not have been sufficiently high. Thirdly, the barrage reached the height of its effectiveness just as the war was ending, and the Germans may not have been aware of the toll being taken in this particular area. This seems to be the most likely reason, for it is one of the advantages of this type of warfare that a submarine destroyed in a minefield has no opportunity to report the position or cause of her loss.

The Folkestone-Gris Nez scheme by no means represented

the final form of the intended anti-U-boat defences in the Channel. Great faith was placed in the loop system of controlled minefields, but one of the difficulties of extending such a system right across the Straits lay in the distance of many of the loops from the shore and the long lengths of cable required. Had the war continued, it was the intention to divide the Channel up into two-mile sections, and to erect a large concrete tower in each section. Each tower, provided with guns and searchlights, was to act as the control station for two loop minefields. This comprehensive and essentially sound scheme, estimated to cost about half a million pounds, was in fact begun, but by the end of the war only one tower had been constructed. This has for many years been the Nab Tower, one of the principal aids to navigation in the approaches to Portsmouth.

In spite of the severe tidal conditions, the Folkestone-Gris Nez Barrage offered a greater practical chance of success than the Northern Barrage. The front to be covered was about ten times shorter, the depth of water was between three and six times shallower, and both ends of the barrage were footed in Allied waters. Although the mines themselves were only effective against submerged U-boats, adequate patrols were available and could be maintained.

1918

In addition to the two major projects just described, various other minelaying operations were carried out in 1918. As we have seen, one of the factors which governed the positioning of the Northern Barrage was the need to cover the Kattegat entrance to the Baltic. Owing to the delay in starting the Northern Barrage, it was decided to lay deep mines in the Kattegat, and in February 1918 the first field was laid by the *Princess Margaret*, the *Abdiel*, and the cruisers *Aurora*, *Penelope*, and *Boadicea*. This penetration into what were potentially enemy waters took on the guise of a Fleet operation, and it is in no way surprising that an escort of one light cruiser and six destroyers was provided, with one battle squadron, one battle-cruiser squadron, and one light cruiser squadron in support. The second operation was delayed by bad weather

until April 1918, when mines were laid by the *Princess Margaret* and *Angora* with similar escort and heavy supporting forces. It seems probable that the efficiency of these fields was reduced due to the premature firing of a number of the mines shortly after laying.

In April and May a series of deep anti-U-boat minefields was also started in the north-western approaches to the Irish sea by the U.S.S. *Baltimore*. British mines were used, with fixed moorings, and as some doubt arose as to the accuracy of the survey, on which the lengths of the mooring ropes had been based, a skimming sweep was carried out to check that no mines were at a dangerous depth. In the course of this sweep, several mines were encountered and a number exploded in the sweep. These proceedings more or less coincided with a marked reduction of U-boat activity in the area, and it was therefore decided to abandon further laying, but it has never been clearly established whether the U-boats had been warned off by the mine explosions or driven off by the improved anti-submarine measures then coming into play. The latter is the more probable solution.

Operations in the Heligoland Bight were continued and intensified, and in February the *Abdiel* proceeded to the Humber to form the 20th Flotilla, consisting of the destroyers *Tarpon*, *Legion*, *Telemachus*, *Ferret*, *Vanoc*, *Ariel*, *Vanquisher*, *Vehement*, *Venturous* and *Sandfly*. The flotilla leader *Gabriel* joined this force in August, and both she and the *Abdiel* were equipped with paravanes. Twelve more destroyers of the V and W class were also equipped as minelayers in 1918, but did not carry out any operations.

In September 1917, the Commander-in-Chief, Grand Fleet, had proposed that the approaches to the German harbours should be mined on a large scale, further destroyers being equipped for the purpose and fitted with paravanes. A passage through our own minefields would have to be swept and the whole operation strongly supported. This proposal was not adopted, as the extensive sweeping operations necessary to ensure the safety of the minelayers and supporting forces would have entirely eliminated the factor of surprise, an essential to the success of such a scheme. The Commander-in-Chief

also proposed that deep mines should be laid at the terminals of the enemy swept routes, and that future laying should be done in sectors, leaving a sector in the centre of the Bight clear. The former proposal was adopted, and the latter in a modified form.

The pros and cons of laying drifting or oscillating mines in the Bight had also been under discussion for some time, and in January 1918 the destroyer *Ferret* laid a field of the oscillating type. This was the only occasion during the war in which these mines were laid, and in view of their limited application and difficulty of manufacture further production was cancelled.

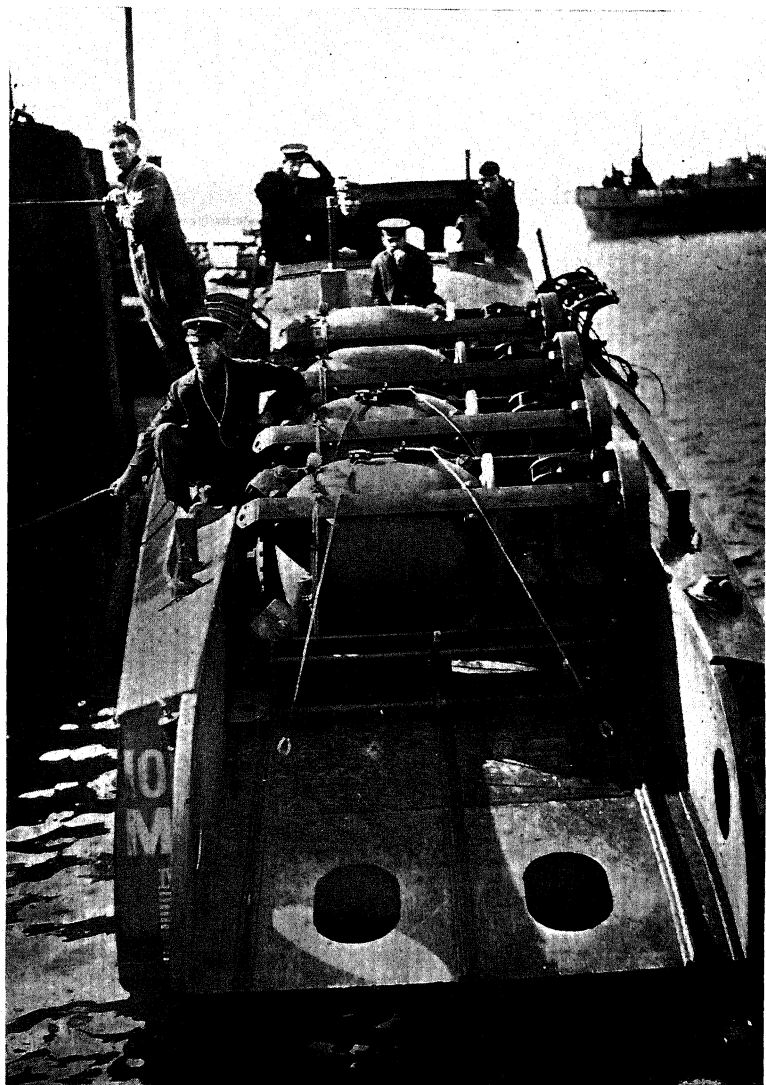
It is of interest that during the discussions which preceded the laying of the Northern Barrage considerable doubt was expressed in some quarters as to the wisdom of our minelaying policy in the Bight. It was contended that no useful purpose could be served by laying mines in areas in which the enemy could sweep them up unhindered; that these minefields had accounted for very few U-boats, and that the proper alternative was to lay and watch a dense *barrier* across the entrance to the Bight. The latter point has already been dealt with in the section on the Northern Barrage, but the other two were equally fallacious. The Heligoland Bight is funnel-shaped, and in the absence of any deterrent the German forces were free to emerge at any point on the seaward perimeter. The only alternative to a dense barrage across the mouth of the funnel was to fill it up by the persistent laying of small independent fields, thus creating a mined area. Admittedly, the mines themselves were comparatively easy to sweep from a technical point of view, but only at the expense of manpower and material which might have been better employed elsewhere. In due course, the sheer weight of the attack tended to swamp the defence, and to all intents and purposes the effect was that of a land-reclamation scheme, through which the German minesweepers could do no more than cut and attempt to maintain a limited number of routes. This not only brought the minesweepers further and further from their bases, but it simplified the task of the British watching forces, while any increased sweeping activity in a particular route served as a pointer to a possible sortie by enemy ships.

The 20th Flotilla and the minelaying submarines continued therefore to lay mines at high pressure, and in the closing stages of the battle were able to concentrate on the enemy routes, the task of the German minesweepers being made more difficult by the introduction of improved anti-sweeping cutters in the mine moorings and in the use of delayed release sinkers. With these sinkers, the mines in any one field were released in groups at varying dates after laying by means of soluble plugs having different rates of melting, the depth-taking being on the hydrostatic principle. A certain number of dummy mines were also laid, as a substitute for those fitted with sinking plugs, which, as already stated, had been found insufficiently reliable to ensure the safety of the minelayers.

To revert to the main purpose and effect of the minefields, it will be seen that without sinking any ships at all they would have forced the enemy to a course of action which he would not otherwise have adopted. In fact, however, some twenty-eight German destroyers and torpedo boats were sunk, together with nearly seventy minesweepers and armed trawlers. These minefields also accounted for at least four U-boats. This comparatively small number was not so much due to the alleged ineffectiveness of the mines as to the fact that their presence forced the enemy to route his U-boats through the Kattegat or to pass them through the inland waterways via Bruges to Zeebrugge and Ostende.

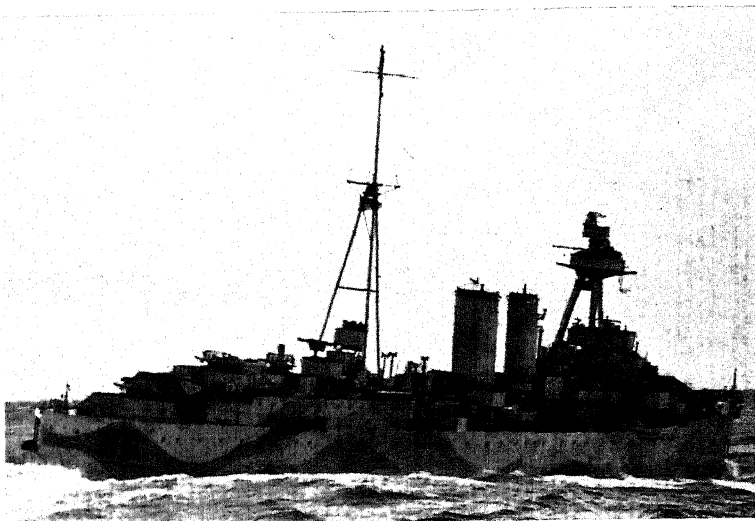
In short, neither a U-boat nor any other craft can be sunk by a minefield if it does not enter it, but to criticize the laying of the minefield on that account is to ignore one of the fundamental principles of mine warfare, and the officers and men who night after night engaged in these hazardous excursions into the Heligoland Bight had more than sufficient cause to be proud of the results of their labours. The *Abdiel*, for example, carried out no less than sixty-eight of these operations, and the *Princess Margaret* twenty-three, in which she laid a total of over 10,000 mines. Several of the destroyers were in the Bight on over thirty-five occasions, and four of the submarines on twenty-five or more each.

Although in the course of these operations the submarine minelayers were frequently subjected to depth-charge attack,



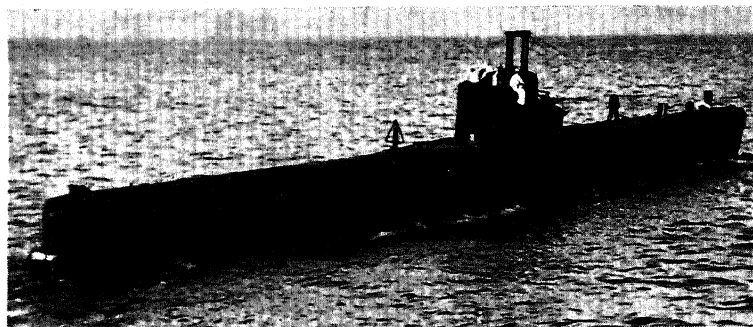
Coastal Motor Boat Minelayer (1917)

(Crown Copyright)



(a) H.M.S. *Adventure*

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(b) H.M.S. *Rorqual*—Minelaying Submarine

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(c) H.M.S. *Abdiel* (1940)

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and the destroyers were embarrassed by the attentions of Zeppelins, the large minelayers were only once intercepted by enemy forces when, in August 1915, the *Mentor*, escorting the *Princess Margaret*, had her bows blown off in an encounter with five German destroyers. It was not until the middle of 1918 that the enemy appears to have endeavoured to lay mines himself as a trap for the British minelayers, and on the night of 1 August the destroyers *Ariel* and *Vehement* of the 20th Flotilla were both mined and sunk. Although operations continued until the Armistice, this episode caused them to be reduced in scope.

By the middle of 1918 supplies of the new ground magnetic mines had begun to come forward, the intention being to adapt several coastal motor boats to lay them close inshore off Zeebrugge and Ostende. Some difficulty arose, however, in the establishment of the necessary arrangements for storage and preparation at Dunkirk, the operational base of the C.M.Bs., and laying was therefore carried out by the destroyers of the 20th Flotilla, who in August and September laid some 400 of these mines off Zeebrugge in three operations, while the *Meteor* laid a further forty off Ostende. Coastal motor boats continued to lay submarine-type mines off the Belgian coast in accordance with the previous policy.

The year 1918 also saw the initiation of one more comparatively large-scale undertaking. It had been appreciated that the laying of the Northern Barrage and the Folkestone-Gris Nez deep fields might have the effect of confining the operations of U-boats to the North Sea, with the consequence of an increased threat to merchant traffic off the east coasts of England and Scotland. Indeed, to have drawn any other conclusion would have indicated a lack of confidence in the two great projects whose avowed purpose was in fact to prevent the egress of U-boats from the North Sea.

The most vulnerable part of the traffic route was considered to be that abreast the Yorkshire coast, and it was therefore decided to mine a large area to seaward of this stretch. Laying was carried out by the *Paris* and the *Wahine*, assisted by destroyers of the 20th Flotilla, and began on 8 August 1918. By the end of October the fields were half completed, but in

two and a half months over 9,000 mines had been laid, a remarkable effort considering the small carrying capacity of the available minelayers.

The laying of controlled minefields off Start Point and Dungeness continued, and further operations were carried out in the Thames Estuary.

In the Mediterranean, operations were confined to the laying of three minefields in the Eastern Adriatic by the submarine E.46, and the reinforcement of the minefields off the entrance to the Dardanelles by the *Biarritz*, the *Perdita*, the French minelayer *Pluton*, and a flotilla of motor launches, while an inter-Allied conference had drawn up proposals for the laying of extensive anti-submarine barrages across the Adriatic and in the Aegean Sea. These schemes, which involved the laying of about 60,000 mines, were not begun, but at the time of the Armistice the preparation of several of the necessary minelaying bases was in hand.

Losses due to enemy minelaying were greatly reduced in 1918, the small monitor M.21 being sunk off Ostende and the destroyer *Kale* in the North Sea, in addition to the *Ariel* and the *Vehement* in the Heligoland Bight. This reduction in losses was probably due to the effectiveness of the Allied measures against U-boats, and to improvements in minesweeping technique and material. Of interest in the latter connexion was a means by which all except the leading ship of a flotilla of minesweepers were protected by the sweeps of the ships ahead of them, while the sweep itself, being towed by a single ship, was easier to handle than the original type towed between two ships¹ (Fig. 27). A high speed mine sweep had also been developed for use by destroyers (Fig. 28).

On the other hand, German losses in the Heligoland Bight, the Northern Barrage, and the Straits of Dover were heavy, while on 20 January 1918, the ex-German battle-cruiser *Goeben* was damaged and the cruiser *Breslau* sunk on the Dardanelles minefield while operating under Turkish control, and in the last days of the war a U-boat was sunk in one of the controlled minefields laid for the defence of Scapa Flow.

By the end of the war, the problem of storage had become

¹ Subsequently developed as the 'Oropesa' sweep.

acute, and large numbers of mines were stocked in the open in various parts of the country.

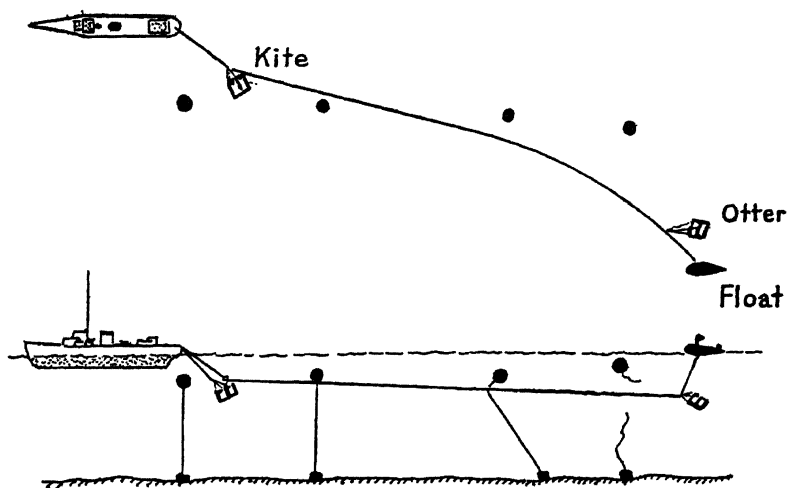


FIG. 27. THE 'OROPESA' SWEEP

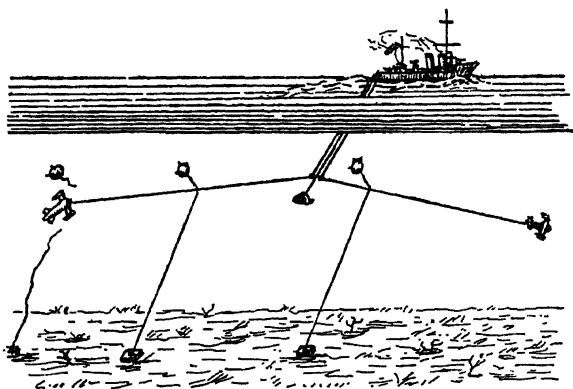


FIG. 28. THE HIGH SPEED MINESWEEP

The 1914-18 Balance Sheet

Having started in 1914 with a virtually empty cupboard and no plans, November 1918 saw Great Britain and the United States of America in the full flood of production and with various extensive minelaying schemes in active preparation.

In the years between, Great Britain had laid over 128,000 mines, of which approximately 40 per cent. were in enemy waters in the Heligoland Bight, the Kattegat, off the Belgian Coast and in the Mediterranean. In addition to her share of the Northern Barrage, large protective systems had been laid in the Dover area, in the Thames Estuary, and off the Yorkshire coast. Small anti-U-boat fields had been laid off the Lizard, Mount's Bay, Dartmouth, Plymouth, Prawle Point, Portsmouth, Portland, Beachy Head, Harwich, Lowestoft, the Humber, Robin Hood Bay, Flamborough Head, St. Andrew's Bay, Tod Head, Lybster, Tarbert Ness and Stotfield. Controlled mine defences had been established for the protection of all the principal harbours.

The United States of America had laid over 56,000 mines in the Northern Barrage with extraordinary rapidity, and their immense resources for the production and laying of mines were about to come into full play when the war ended.

As a result of these activities, approximately 150 enemy war vessels and naval auxiliaries were sunk, including some 35 U-boats.¹

The Germans laid over 43,000 mines, the great majority in innumerable small fields round the coasts of Great Britain, France, Italy and Greece, along the eastern shores of the Adriatic, off the Tunisian coast, in the Baltic and the Black Sea, in the approaches to the White Sea, and in Pacific and Eastern Waters. These mines inflicted on the British Empire alone the loss of 40 war vessels, 225 auxiliaries, 63 fishing craft and 260 merchant ships. The total Allied loss in the latter category due to enemy mines was 586 ships, representing 1,000,000 tons.

The Russians laid a considerable number of minefields in the Baltic, the Black Sea and the Gulf of Finland. The French assisted in the Mediterranean, while Italian minelaying was chiefly confined to protective fields off their own coast. They carried out several offensive operations off the eastern shores of the Adriatic, however, in some of which their small high-speed craft played a prominent part. The majority of the

¹ It will be appreciated that mining casualties are not always possible to assess with precision. This is particularly so in the case of U-boats.

neutral maritime nations in Europe laid small minefields for the defence of their own territorial waters, and in all the total number of mines laid by belligerents and neutrals was of the order of 240,000.

It has not been possible to describe in detail the many ingenious schemes and devices tried out, or to give more than an indication of the prodigious development in the design and production of British mining material and of the skill and determination with which it was handled by the minelayers. It is, however, worth noting that the Germans needed to do no more than effect minor improvements to the mines with which they started the war, and were only beginning to be confronted with a serious mine-sweeping problem in the concluding months. Other countries do not appear to have developed their material to any appreciable extent.

Given comparable material ourselves on the outbreak of war, it is debatable whether we should necessarily have achieved better results, but it is suggested that we might have achieved at least the same results with a smaller expenditure of money and material.

CHAPTER VI

BETWEEN THE WARS

(From 1919 to 1939)

THE end of World War I found Great Britain with a stock of some 60,000 efficient mines and a wealth of accumulated technical data. Operational experience had also been gained, but much of it was undigested, and opinions remained divided as to the real value of the weapon.

We were in fact too near the actual events for a proper appreciation to be made, and so there was a tendency to confuse cause with effect and to substitute catch-phrases for principles. Fortunately, there was not a complete reversion to the pre-1914 attitude, and a nucleus of the scientific and design staff was retained at Portsmouth under a Superintendent of Mine Design, with a section of H.M.S. *Vernon* charged with the conduct of sea-trials of new material. It was, however, inevitable that progress, in addition to being slowed up by the need for economy, should be in the technical rather than in the operational sphere, and some years were to elapse before the employment of the mine began to form an integral part of British war plans.

It will therefore be convenient to treat the period between the two wars under the separate headings of Mines, Minelayers, and Production, leaving the consideration of policy and planning to the subsequent chapter which deals with World War II.

Independent Mines

Reference has been made to the successful type of moored contact mine produced in 1917, and known as the H.II (Fig. 29). The mine was spherical in shape and carried a charge of 320 lb. of explosive. Four Herz horns were fitted in the upper hemisphere, and two more in the lower, the object of the latter being to increase the chances of success against a submarine. The mine could be laid in depths of water up to 200 fathoms (later increased to 600), and the

depth below the surface could be adjusted before laying up to a maximum of 300 feet. The sinker was of the plummet type, but greater accuracy of depth-taking at laying speeds up to 20 knots was achieved by keeping the mine and sinker together on the surface until they had reached a state of equilibrium clear of the disturbed water astern of the mine-layer. The cycle of events in this design, known as the 'buoyant combination', is shown on Fig. 30. The greater depth setting was achieved by the fitting, when required, of a depth reel carrying an additional length of wire to increase that normally provided for the plummet.

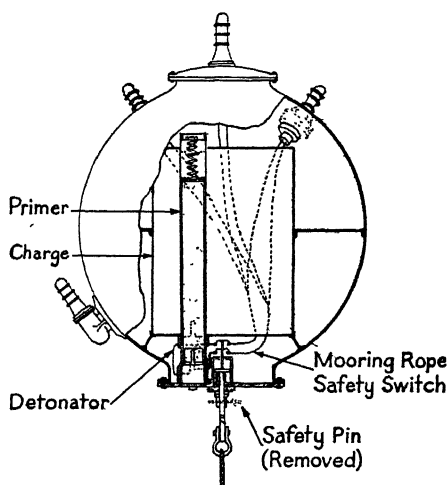
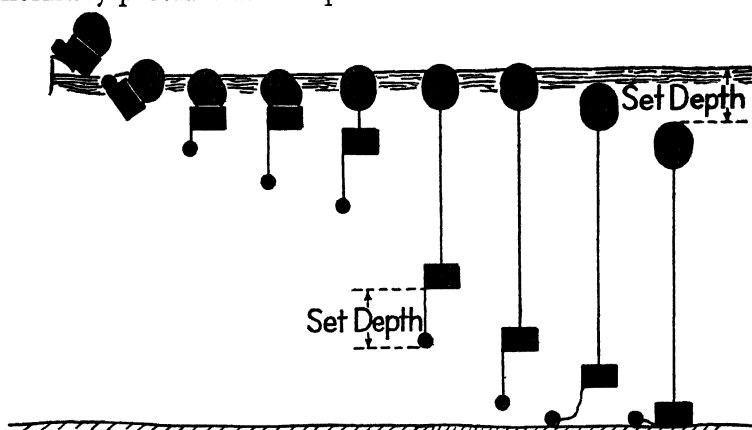


FIG. 29. THE BRITISH H.II MINE

FIG. 30. THE PLUMMET SYSTEM OF AUTOMATIC DEPTH-TAKING
(BUOYANT COMBINATION)

Many of the features embodied in this design remain standardized to-day, but the unit as a whole suffered from

certain limitations, and steps were taken to effect the necessary improvements.

In the first place, the tidal performance was low. As already noted, one of the limitations of a moored mine is that it dips in a current. Further, it must be laid so that it is always below the surface at *low water*, partly to prevent sighting by the enemy and partly to avoid the effects of heavy seas. Thus when the tide rises the mine will be deeper than at low water, and the combination of dip and tidal range means that there will be periods during which ships of a given draught can pass over a field of moored contact mines in safety. A typical state of affairs is shown on Fig. 31, where it will be seen that a

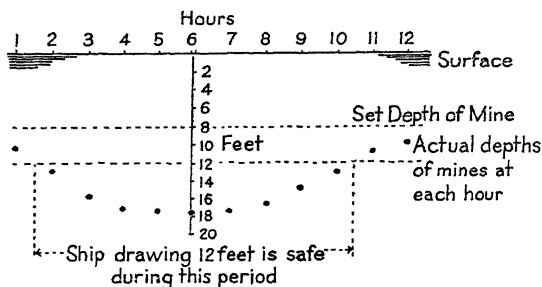


FIG. 31. EFFECT OF 'DIP' AND RISE AND FALL OF TIDE

ship drawing 12 feet might pass in safety over a minefield laid at 8 feet for approximately nine hours out of the twelve.

It should also be realized that the depth setting must be adjusted to take account of the state of the tide *at the time of laying*. For example, if the mines are required to be 6 feet below the surface at low water, and the height of the tide is 4 feet at the intended time of laying, the actual depth adjustment must be 10 feet. If for any reason the mines are laid at some other time than that originally intended, then the depth setting must be altered to conform to the different state of the tide at that time.

The obvious solution to all these problems would be a mine which always remained at the same depth below the surface. Indeed, a vast number of proposals for what are generically known as 'tide compensators' have been put forward, but in practice these devices all fail for one reason or another.

Although nothing practicable could be done about the rise and fall of the tide, it was decided to reduce the tendency to dip by increasing the positive buoyancy of the mine: that is to say, by increasing the upward pull exerted by the mine. This meant a larger air space in the mine, which, coupled with the general desirability of increasing the weight of explosive, meant a larger mine. As a large spherical mine would have introduced difficulties in manufacture, handling, and laying, it was decided that the new mine should be drum-shaped with hemispherical ends. As the size of the mooring rope also affected the tendency to dip, efforts were at the same time directed to the production of smaller wires for the same strength, while the depth in which the mines could be laid was increased to *one thousand fathoms*, or one mile. Even with a fine wire, the latter requirement meant a large mooring rope drum, and therefore a large sinker to carry it, but in any case the increase in the size and buoyancy of the mine would have meant a larger sinker, both to carry the mine before laying and to prevent dragging when laid.

But a larger sinker meant an increase in the gauge of the mine rails, which in turn affected the structural layout of the minelayers. Serious objection on the latter score might well have wrecked the whole cycle of development, but happily such objections were overruled and there emerged the Mark XIV mine (Fig. 32).

Two other important improvements remain to be noted. In the earlier mines, the explosive charge was inseparable from the mine

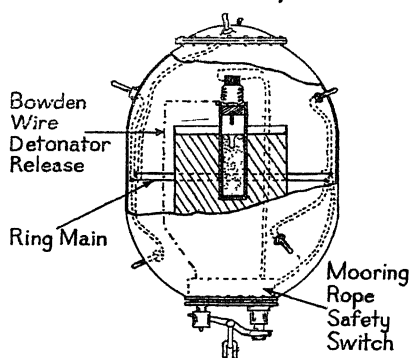


FIG. 32. THE BRITISH MARK XIV MINE

case, and when stored under what are known as 'magazine conditions' space had to be found for the whole mine, a very grave disadvantage. In the new mine, a detachable charge case was incorporated, which could be stored separately and inserted in the mine when preparing for service.

An incredible amount of magazine space was thus saved, while two different sizes of charge could be provided, weighing 500 and 320 lb. respectively. The latter was essential for laying in great depths of water or in strong tides in order to increase the air space in the mine and so increase the positive buoyancy. It is of interest that the detachable charge case was by no means a novel conception, having been incorporated in the Greenham mine designed in the year 1890.

The second improvement was in the method of depth adjustment. Previously, the plummet wire had to be cut to the required length before fitting, and rapid change in the setting was therefore impracticable. In the new mines, the amount of plummet wire to be run off could be set by a simple adjustment in steps of 1 foot up to a maximum of 33 feet. For any greater depth, depth-reels of fixed length were provided in addition, so that any setting from 3 to 303 feet could be made in steps of 1 foot.

The Mark XIV mine was fitted with fourteen Herz horns, but it was found that a relatively severe blow might on occasion fail to fracture the glass tube, and that mines so fitted were liable under certain conditions to be countermined by the explosion of an adjacent mine. In addition, manufacturers had found difficulty in meeting the necessarily rigid specifications for the glass tubes, and so it was decided to adopt an alternative system in which the Herz horns were replaced by switch horns. The latter were in effect spikes which, if moved in any direction, completed the circuit from an electric battery to the detonator. This arrangement overcame the defects of the Herz horn, but it represented a reversal of opinion with regard to the incorporation of electrical firing, it being remembered that the supreme advantage of the Herz horn lay in the fact that it could not *become* an electrical battery until struck by a ship, and it had an unlimited storage and operational life. However, the development of a reliable dry cell was in any case stimulated by the introduction of other electrically operated devices to be described later, and this change of policy was more or less inevitable. The switch horns were incorporated in the Mark XV mine, an improved version of the Mark XIV. In the writer's view, however, the

Herz horn embodied the most satisfactory principle ever evolved for the firing of a contact mine.

In the course of time, it was realized that both the Mark XIV and Mark XV mines might prove to be unsuited to quantity production in war, and the Mark XVII was therefore developed, which with its sinker differed only in constructional details from the Mark XIV.

As will be seen later, it was decided to build submarine minelayers—that is, submarines whose primary purpose was to lay mines, as opposed to the World War I practice of adapting existing submarines to this service. This decision entailed the design of a moored mine, to be known as the Mark XVI.

The requirements for submarine laying imposed certain limitations, the most important consideration being that the act of laying should not disclose the presence of the minelayer. This involved the adoption of hydrostatic depth-taking, in which system it will be remembered that the mine and sinker go to the bottom together, the mine then becoming detached and rising to its set depth. The depth of water in which such a combination can be laid is thus limited by the crushing strength of the mine-shell. Secondly, it was desirable to carry as many mines as possible in the space available while at the same time incorporating a worthwhile explosive charge.

The compromise finally reached was a Herz horn mine with a charge of 320 lb. of T.N.T., carried on a hydrostatic type sinker and capable of being laid in depths of water up to 80 fathoms. It could be set to take up any depth between 5 and 90 feet below the surface, these limits being those over which the spring of the hydrostatic valve could be calibrated with the necessary accuracy. The depth-taking mechanism was arranged on a new system known as the 'loose bight', shown in Fig. 33, which overcame the difficulties encountered with the earlier pilot-wire method of locking the mooring-rope drum. In addition to the above limitations inherent in the hydrostatic type of depth-taking mechanism, it should also be noted that such mines must be laid at or very near slack water. If, as shown in Fig. 34, they are laid at any other time, then they will be *above* their set depth when the period of

slack water does come, and may shallow to an undesirable extent.

It will thus be seen that many restrictions on the design of this mine were accepted in order to meet the overriding

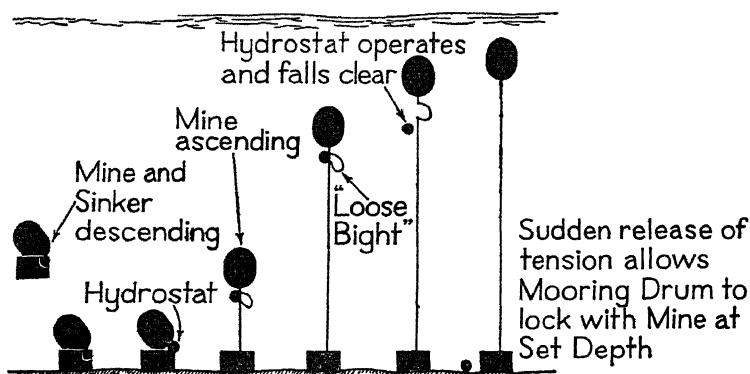


FIG. 33. THE 'LOOSE BIGHT' SYSTEM OF HYDROSTATIC DEPTH-TAKING

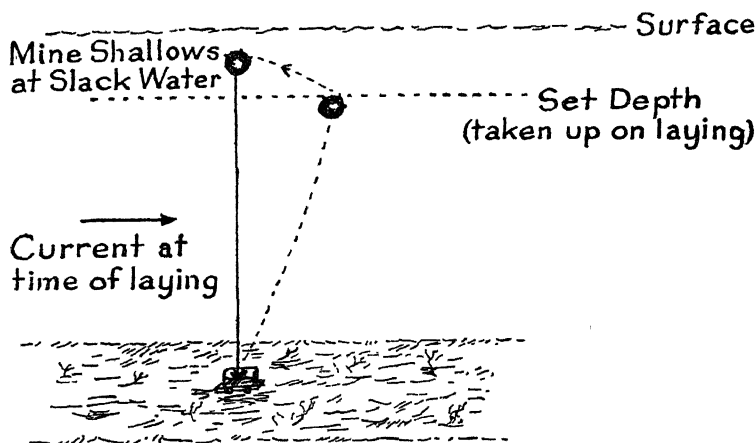


FIG. 34. HYDROSTATIC DEPTH-TAKING. EFFECT OF CURRENT

requirement for secrecy in laying. A plummet type combination in which the mine did *not* appear on the surface would have filled the bill, i.e. a mine which hovered below the surface while the sinker was descending to the bottom. Attempts were in fact made to produce such a combination,

but the project was dropped in view of the many technical difficulties encountered and the expectation that submarine minelayers would normally work inshore in less than 80 fathoms of water. Had it been foreseen that Norway would one day become an enemy-occupied country, more consideration might have been given to the problem, it being noted that the water gets *deeper* as one approaches the Norwegian coast.

The antenna system was not developed, except in so far as was necessary to investigate its effectiveness as an anti-paravane weapon, it being known that there was available a commercial mine of this type.

Non-contact Mines

When formulating the minelaying policy to be adopted had World War I continued, the British Naval Staff considered it to be axiomatic that only those types of mine incapable of being swept should be laid in enemy waters. They were, of course, impressed by the fact that in the acoustic and magnetic ground mines then coming into service we had something which the Germans could not sweep. With great respect to the Staff, it is however suggested that they had in fact enunciated a principle which was all the more dangerous for being very nearly true. The non-contact mines then available to us could not be swept by the Germans *at the time*, but there was no sort of reason why this state of affairs should have continued. In short, there neither was nor is any such thing as a permanently unsweepable mine, and acceptance of the Staff dictum at its face value would in due course have relegated the weapon to a purely defensive role. In actual fact, this is very nearly what happened, simply because the technical staffs were not in a position to foresee the immense potentialities of the non-contact mine. It was, however, gradually appreciated that the laying of mines in enemy waters would continue to be a worthwhile proposition provided that the mines employed could be made increasingly *difficult* to sweep, as opposed to being impossible to sweep, and that even a comparatively simple mine could be effective if used with imagination, and with an understanding of enemy psychology.

It was with this background, therefore, that we proceeded with the development of non-contact mines and anti-sweeping devices, and the foregoing dissertation is in no way intended as a reflection on either the Naval Staff or their technical advisers. The former could obviously do no more than see the existing wood, while the latter could not possibly foresee the ultimate growth of the trees.

Priority of development was accorded to magnetic rather than to acoustic methods of actuation, the chief reason being that the magnetic properties of various types of ship were more capable of classification than were the acoustic characteristics, and it was therefore possible to calibrate a magnetic system and gauge its probable performance with more accuracy. In the light of the available resources for design and trial work, this policy was sound, but it by no means involved a complete neglect of acoustic problems. Much of the data collected on the propagation of sound under water was to prove invaluable in the years to come.

It was also decided that the development of a *buoyant* magnetic mine should take precedence over that of a ground magnetic system. It is of interest that this decision, which had rather far-reaching effects, was to some extent based on a misconception. In World War I the mine had proved to be very nearly as effective as the depth-charge, considered solely in terms of the actual *number* of U-boats destroyed by either method. It was therefore concluded that the mine was not only a valuable anti-U-boat weapon, but that everything possible should be done to improve its effectiveness as such. Full-scale trials against ex-German submarines having shown that an explosive charge of 500 lb. would probably not be effective against such a vessel outside a range of about 20 feet, it followed that a non-contact anti-U-boat mine for use in normal depths of water must be of the buoyant or moored type.

It is suggested that it would have been more correct to interpret the war figures as showing that in spite of the fact that the methods of detecting and locating a submarine were practically in their infancy, the depth charge accounted for slightly more U-boats than did the mine. In other words,

there was a certainty of considerable improvement in a tactical method of dealing with these craft in which the depth-charge merely took its place as the ultimate medium of destruction, whereas the mine must remain a static weapon whose technical effectiveness could only be increased within certain prescribed limits.

In considering these points, it must not be forgotten that the introduction of a moored non-contact mine was also of importance for anti-surface ship purposes. Further, and of even more importance, such a mine served to ameliorate the effects of dip, in that a ship which could pass over a field of moored contact mines in safety might still be endangered if they were of the non-contact type. None the less, the foregoing decision, coupled with the shortage of staff and trial facilities, did result in the development of the much simpler ground magnetic mine being slowed up, with the further consequence that its potentialities were neither proved in full-scale trials *against ships* nor could the need be appreciated to allocate money and resources to the development of the antidote.¹

When dealing with the latter subject, however, we shall see that the work done on magnetic problems before the war was to be one of the primary factors in the defeat of the German version of the magnetic mine.

It is well known that in the process of building, a steel ship acquires a certain amount of what is called permanent magnetism. She subsequently acquires a varying amount of induced magnetism due to her faculty of causing a concentration of the earth's magnetic field. In both cases she is regarded as being magnetized in three directions: longitudinally, vertically, and athwartships, and the general conditions may be summarized as follows:

Longitudinal Magnetization

Permanent longitudinal magnetization varies considerably in different ships, depending as it does on the direction of the ship's head when building, the place where she is built, and

¹ Trials were indeed carried out against fabricated targets designed to represent full-scale *sections* of various types of ship. The devastating effects of the 'whipping' of a full-length hull when subjected to an explosion some distance beneath the ship were therefore not apparent until actually experienced in war.

the method of construction. Once acquired, it remains stable, but may undergo minor modification as the result of firing guns, the hammering received when refitting, or possibly the effects of vibration and heavy seas.

Induced longitudinal magnetization varies continually, being dependent on the magnetic latitude and the direction in which the ship is heading.

Vertical Magnetization

Permanent vertical magnetization is not in actual fact permanent, as it may vary on a long voyage, particularly if excessive vibration is experienced.

Induced vertical magnetization changes according to the magnetic latitude of the ship.

Athwartships Magnetization

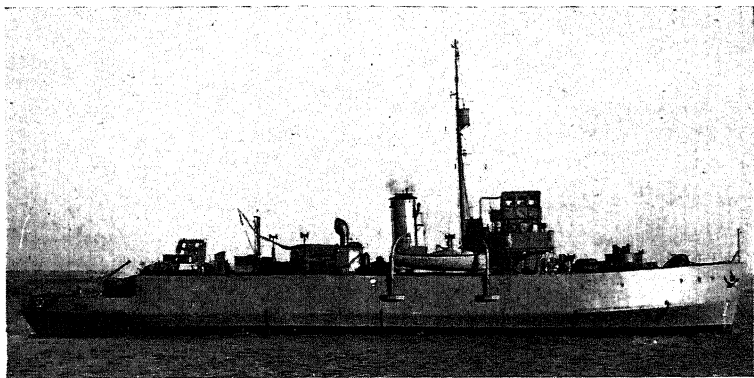
For permanent and induced athwartship magnetization, the considerations are precisely the same as for longitudinal magnetization.

It will thus be seen that the only factors likely to remain constant over extended periods are the permanent magnetization in the longitudinal and athwartship directions.

For the purposes of explanation, it is convenient to represent the direction of the earth's magnetic field by parallel lines of force, and the strength of the field by the number of such lines passing through any area which may be chosen to represent unity. A variation in the strength of the local field due to the introduction of a permeable body such as a bar of soft iron or a ship will thus be represented by a bunching of the lines of force, the adjacent weakening of the field being represented by a displacement of the lines to a greater distance apart than the normal.

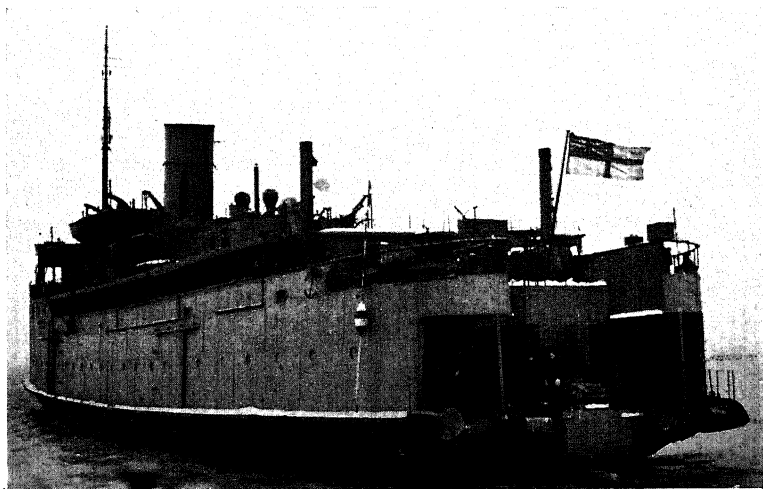
Figs. 35 and 36 show the approximate state of affairs in the waters around the United Kingdom, and in this area a magnetized needle free to swing in any direction will point towards the magnetic north, with its north-seeking end down and its axis at an angle of about 66 degrees to the horizontal.

It is always simpler to measure a force if it is acting either



(a) H.M.S. *Plover*

(Crown Copyright)



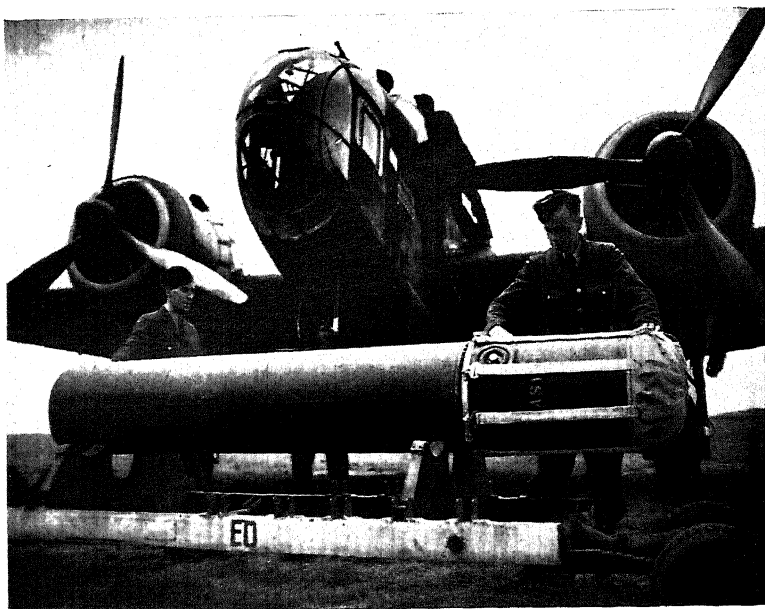
(b) H.M.S. *Princess Victoria*

(News Chronicle)



(c) H.M.S. *Southern Prince*

(Crown Copyright)



(a) Minelaying Aircraft and Magnetic Mine

(Central Press)



(b) Minelaying Motor Launches

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in a horizontal or in a vertical direction, and in the case of the 1918 British magnetic mine the dip-needle principle referred to above was employed. The Germans, in developing

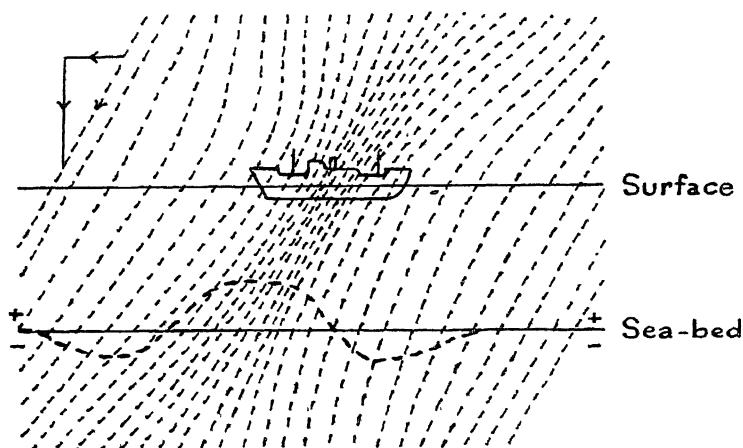


FIG. 35. A SHIP IN THE EARTH'S MAGNETIC FIELD

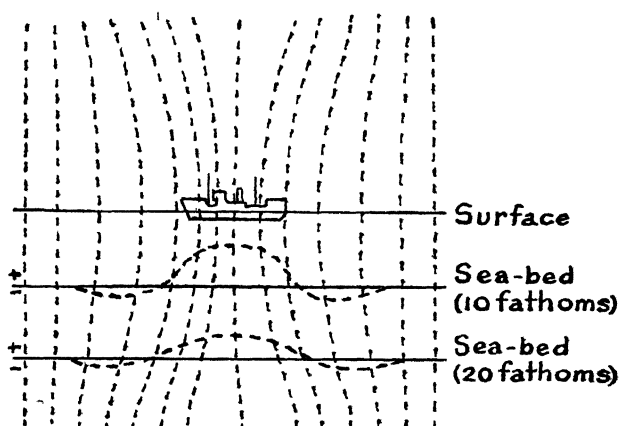


FIG. 36. A SHIP IN THE VERTICAL COMPONENT OF THE EARTH'S FIELD

their magnetic mine between the wars, committed the error of adopting the same principle. In their mines, a small magnetized bar, pivoted to allow movement in the vertical

plane, was retained in the horizontal position by a helical spring, the tension in the spring being adjusted to balance the *vertical* component of the earth's field, and so prevent the bar from dipping. The increase in the vertical component of the earth's field due to the presence of a ship overcame the tension in the spring, so causing the bar to dip and the circuit between the firing battery and the detonator to be completed.

The graphs in Figs. 35 and 36 show the variation in the intensity of the earth's magnetic field beneath a typical ship, or what is generally referred to as the 'signature' of the ship. Fig. 36 also shows how the signature weakens as the distance beneath the ship is increased.

The German mine, in short, worked on an *increase* in the vertical component of the magnetic field, and although simple in theory it had many practical disadvantages. These will be dealt with in more detail when we come to consider the technical battle waged in World War II (Chapter VII). The interesting point to note here is that the *permanent* magnetism of ships was of secondary importance in countering the German mine as first produced.

In about 1931 the dip-needle principle was discarded by the British in favour of a system which employed a solenoid consisting of many turns of fine wire wound round a rod of a highly permeable nickel-copper-iron alloy known as Mu-Metal, which might perhaps be called the 'secret' of our development. The system as a whole was given the title C.R. (for coiled rod), and depended on the small current induced in the coil by the movement of a ship over the mine, or in other words on the *rate of change* in the strength of the magnetic field as opposed to an *increase* in the strength of the field. In the moored version of the British magnetic mine, known as the M. Mark I, the C.R. rod had of necessity to be placed vertically, and it had to be comparatively short. This latter disability was partly overcome by making the upper and lower hemispheres of the mine shell part of the magnetic system, the central belt being of non-magnetic material. Nevertheless, the mine had to work on the vertical component of the magnetic field, whereas in the ground mine, which was torpedo-shaped, the C.R. rod could be of considerable length and arranged to

run horizontally through the mine. It was therefore possible in this case to work on the horizontal component of both the permanent and the induced magnetic field, one of the factors tending to make the British mine more difficult to counter than the German version. In both the moored and the ground magnetic mines the small current induced in the solenoid was employed to operate a sensitive relay and so close the firing circuit (Fig. 37).

The British aircraft-laid ground magnetic mine, known as

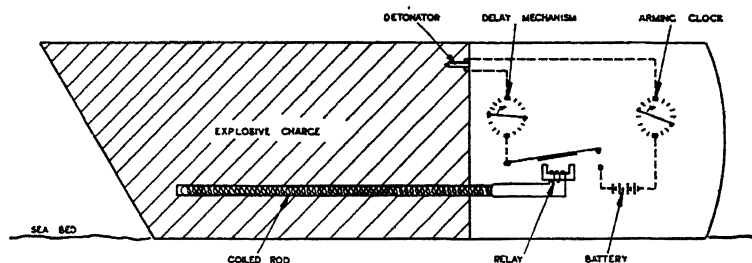


FIG. 37. BRITISH MAGNETIC GROUND MINE

the A. Mk I, was about to go into bulk production on the outbreak of war. The M. Mk. I was already in production.

It will be appreciated that the currents generated in this manner are not very large. It would, in fact, take about 35 million detecting units to produce sufficient power to light one small torch bulb.

Anti-Sweeping and Other Special Devices

With regard to special devices designed to make things more difficult for the enemy, the sprocket wheel type of sweep evader, already described, was unearthed and its original defects remedied. Two other anti-sweeping devices, both of the snag type, were also developed, the grapnel and the explosive grapnel. The former, an old idea in itself, was designed to ensure that a mine mooring cut by a sweep would hook itself on to the sweep wire, to the ultimate discomfort of the minesweeper. The explosive grapnel was intended to sever the sweep wire by means of a sharp cutter driven against the wire by the explosion of a small charge of gunpowder. During World War I a number of similar devices had been

produced, but static obstructors, i.e. high buoyancy floats with grapnels, cutters, saw-teeth, explosive charges, etc., fitted to the mooring ropes were not adopted as standard articles in peace. It was felt that they could very simply be improvised if required, and that as a matter of general policy it would be better to incorporate snags or evaders in the moorings of live mines rather than take up space on the rails of a minelayer by carrying non-lethal objects.

The Germans, on the other hand, and to a lesser extent the Italians, developed some really vicious types of obstructor, and in World War II were to lay a high proportion of these devices in many of their minefields. In the opinion of those qualified to judge, they overdid it, for however embarrassing these measures may be to the minesweepers, they do not themselves sink any ships. These two countries also used lengths of chain in the upper parts of their mine moorings, and we should have done the same but for the inescapable fact that the necessary chain was not available.

Anti-recovery devices and booby traps were not developed by Great Britain, for two reasons. In the first place, no mechanism made by human hands can be 100 per cent. reliable, and to rely on such methods to preserve the secrecy of any special type of mine which may fall into enemy hands is simply to indulge a false sense of security. Secondly, every additional fitting of this nature increases the chances of a mine failing to function correctly. The Germans adopted the opposite policy, to the benefit of Great Britain.

Finally, a delayed release sinker was produced, which may be classed as an anti-sweeping device, in that it caused the automatic replenishment of a minefield after the area had been swept by the enemy and pronounced clear. In this arrangement, the mine remained secured to the sinker by a wire strop. After a pre-set time, an electric clock on the sinker fired a small explosive cutter which severed the wire, and the mine rose to its set depth. Depth-taking under these conditions obviously had to be on the hydrostatic principle, and, as in the case of the Mark XVI submarine-laid mine, the depth of water in which these sinkers could be used was limited to 80 fathoms. It has already been pointed out that normally

the depth set on a mine must take account of the state of the tide at the time of laying, which in this case became the *time of release*.

This called for great accuracy in timing, and in this respect the electric clock was far superior to the soluble plugs used for the same purpose in the Heligoland Bight, as described in the previous chapter. Similar clocks were also adapted to perform the function of the sinking plugs used in World War I, and it was the introduction of these electrically driven clocks which stimulated the search for a reliable dry battery, referred to earlier in connexion with the substitution of switch horns for the Herz horn method of firing.

Controlled Mines

The loop system of controlled mining, as already noted, had been evolved in the closing stages of the war. The essential feature of the system was a loop of electric cable laid on the bottom of the sea, enclosing an area measuring about 600 yards by 25 yards (Fig. 38).

On the principle of the simple dynamo, a steel ship crossing this area induced a small current in the loop, the magnitude of this current being increased by the use of multicore cable. The current was carried by a 'tail' cable to a control station on shore, where it was amplified and caused to deflect a sensitive galvanometer. The deflection of the galvanometer was in turn amplified by a small lamp and mirror to move a spot of light across a transparent screen, thereby indicating the passage of a ship over the loop.

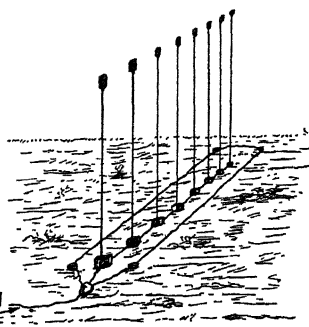


FIG. 38. A 'LOOP' CONTROLLED MINEFIELD

A row of mines was laid down the centre of the loop, the moorings consisting of twin-core armoured cable. The sinkers of the mines were connected by similar cable, the cores being led ashore through the tail cable referred to above and connected to a firing generator in the control station, from which

all the mines in a group could be fired simultaneously. The defences of a harbour normally consisted of several of these mine loops, while to seaward of the main defences less sensitive loops were laid, without mines. These were known as guard loops, their purpose being to indicate the approach of a vessel and so bring the defences to the alert.

The above is a brief description of the system as finally perfected, but extensive experiments and trials were required in connexion with such matters as the movement of the loop cable in the earth's magnetic field when laid on an uneven bottom; stray currents set up by disturbances ranging from freak terrestrial conditions to the operations of local tramway undertakings; the provision of reliable insulation and cable connexions; and above all the establishment of a sound firing rule to ensure that the mines were fired when the target vessel was actually over the loop.

It should be emphasized that the whole system—loop, mines, and all connecting cables—was designed to be accurately laid by one ship *in one operation*, and a glance at Fig. 38 will give some idea of the care required in rigging, to say nothing of the seamanship displayed in laying.

The main disadvantage of the loop system lies in its complication and heavy overhead costs, and in the necessity to provide specialized craft and skilled personnel for laying, maintenance, and operation. In providing for the permanent underwater defences of an important harbour, however, such things must be accepted; the operational weakness arising from the fact that the explosion of a group of mines left a gap in the defences was of rather more importance, but could be reduced by care in the planning and laying of the defences.

On balance, the system solved nearly all the problems with which earlier efforts had been confronted, in that it gave a warning of the approach of a hostile vessel, whether on the surface or submerged; it indicated the correct moment at which to fire; it provided an adequate explosion; it was effective by night as well as by day, and it allowed the safe passage of friendly ships.

As in the distant past, an organization was also set up for the transport and rapid laying of this type of defence for the

protection of a temporary fleet anchorage, the control huts and their associated equipment being designed to be easily portable and quickly erected. In actual practice, the limiting factor was the time taken for the setting of the concrete which formed the rigid support for the delicate indicating galvanometers.

Countermeasures

As already noted, countermeasures involve both the sweeping of the mines themselves and the self-protection of ships. In so far as moored mines were concerned, efforts were directed in the first place to improved *performance*, particularly in the case of the Oropesa sweep described in the last chapter, and, secondly, to increased *effectiveness*. The object was to produce as flat a sweep as possible, i.e. one in which the wire remained as nearly horizontal as possible throughout its length, and also to increase the spread of the sweep. In the latter connexion, the important point is that for a wire of given size and strength the speed of sweeping and the spread of an Oropesa type of sweep are interdependent; that is to say, increase in the one cannot be effected without reduction in the other. Improvement in the performance of this sweep thus involved the production of better wires and the substitution of multiplane otters for the earlier and cruder methods of spreading. Increase in effectiveness by the fitting of cutters to the sweep wire involved considerable research and experiment, not only to establish the best form for the cutters themselves, but also the intervals at which they should be spaced along the wire.

The high-speed mine sweep, to which reference has been made, could by definition only sweep a narrow path. The two-speed destroyer sweep was therefore evolved, which gave a spread of about 450 yards at the slower speeds. If speed was increased above a certain limit, the increased pressure on the planes of the otters, overcoming a strong spring, caused the angle of incidence of the planes to alter, so reducing the spread of the sweep to about 150 yards, and with this spread sweeping could be carried out at speeds up to 25 knots. If speed was then reduced below the lower setting of the sweep,

the spring took charge again and altered the angle of incidence of the planes to give the broader spread. It will be understood that it was never intended to use destroyers to clear a mined area, except in emergency, the primary object of the sweep being to enable them to search the water ahead of the fleet.

With regard to self-protection, paravanes were retained and improved, particularly for use at high speed, but the advent of the non-contact mine necessitated an entirely different approach to the problem.

From 1919 onwards, extensive investigations were made with a view to classifying the magnetic properties of ships, and a wealth of technical information was collected and analysed. As already described, the loop system was improved and a magnetic mine which operated on a different principle to the 1918 type was designed. In passing, it should be noted that a non-contact torpedo was also evolved.

By 1935 it had become obvious that progress had reached a stage at which the consideration of a counter to these devices was due, if not overdue, and some preliminary suggestions were put forward by H.M.S. *Vernon* in conjunction with the Mine Design Department. The matter was clearly of such importance, however, that an Admiralty Anti-non-contact Committee was set up in 1936 to examine the whole question. There were two broad lines of approach to be considered: either actuation of the firing mechanism at a safe distance, or rendering the ship magnetically non-existent.

In theory, the latter alternative could be achieved by fitting a number of suitably disposed wire coils carrying an electric current, but in practice the problems was by no means simple. For reasons which have already been stated, we were rather preoccupied with the menace presented by *moored* non-contact mines and by non-contact torpedoes, both of which were expected to be adjusted to fire fairly near to their objective. Investigation had shown the magnetic conditions in the close vicinity of the hull of a ship to be extremely inconstant, and as the induced longitudinal and athwartship magnetism varies with the direction in which she is heading as well as with the magnetic latitude, absolute demagnetization was considered to be *impracticable*.

Initial attempts were therefore directed to the *over*-magnetization of ships to such an extent that firing mechanisms operating on magnetic principles would be actuated at a safe distance.

In 1937 full-scale trials on these lines were carried out in the cruiser *Curacoa* and much valuable information obtained. It was, however, realized that over-magnetization was not in itself the complete solution, as the enemy, by *reducing* the sensitivity of his mine-actuating mechanism, would be able to endanger a ship so treated. It will also be appreciated that full-scale trials of this type, although a satisfactory method of testing both the value and the practicability of any particular system, were too cumbersome and expensive for the purpose of detailed scientific investigation. An ingenious method of simulating the magnetic properties of various types of ship on a model scale was therefore evolved, and the possibilities of demagnetization further pursued.

The foregoing measures were all directed to the self-protection of ships against magnetically operated mines. The parallel problem of *sweeping* these mines was also attacked. In the case of buoyant mines, no great technical difficulty arose, as normal wire sweeps could be used, but the problem of increased danger to the minesweepers themselves remained. In the case of ground mines, we had by the outbreak of war in 1939 not advanced much further than the towing of a bottom sweep to which a number of permanent bar magnets were attached.

The position may be summed up by saying that when World War II broke out we *knew* a lot, but we could not *do* a lot until we discovered what type of non-contact mechanism the enemy was employing, and further consideration of the matter is therefore best deferred to the next chapter.

One other measure, however, evolved in peacetime for the protection of ships in war deserves mention. This was the 'Q' message system, a standardized and practised method whereby mine-warnings could be promulgated rapidly to H.M. ships and to the authorities responsible for the safe routing of merchant ships. In very broad terms, the policy adopted was to inform H.M. ships of the actual nature and extent of the dangerous areas, so as to afford them the maximum freedom of movement, and to inform others of the nature of

the routes to which they must adhere in order to keep clear of danger. The system, for reasons which we shall see, was also extended to the issue of warnings about British as well as enemy minefields, and also embraced navigational warnings and details of secret swept channels, the security grading of the messages being adjusted according to the type of information and the status of the recipient.

Minelayers

For laying mines in enemy waters, the experience of World War I had suggested that mine-carrying capacity was of less importance than the power of evasion conferred by high speed, small silhouette, or the ability to submerge. On the other hand, for barrage laying in waters over which we exercised control, mine-carrying capacity and good sea-keeping qualities appeared to be of more importance than speed, because the greater the number of mines laid at a time the fewer the gaps left by the necessity to keep the minelayers clear of mines already laid. For either purpose, ability to navigate with accuracy was essential.

The war had also shown the ease with which almost any type of vessel could be adapted to lay mines, and in consequence some differences of opinion arose over the necessity to include in the peacetime fleet ships specifically designed and built as minelayers.

For barrage laying in open waters, it was generally conceded that converted merchant ships would be suitable, provided that their bulk did not introduce maintenance and berthing problems, and for laying in more protected waters it was agreed that specialized craft, such as train ferries, would meet requirements and would be readily convertible.

It was on the question of minelaying in enemy waters that opinion was most sharply divided. As already stated, the primary requirement was speed, and only two types of merchant vessel could provide that speed. On the one hand, there was the large passenger liner, a type obviously too bulky and vulnerable for the purpose. On the other hand, there was the small steamer of the cross-Channel type, unsuitable on account of her small radius of action, comparatively poor sea-keeping

qualities, and light structure. The whole issue was confused by the fact that the *Princess Margaret* had been employed with success in this capacity. She had, however, been designed and built specially for the run between Seattle and Vancouver, and was more or less unique, and it was indeed unfortunate that her magnificent performance in laying over 10,000 mines in enemy waters, coupled with the need for strict economy, should have had such a baleful effect on policy.

Actually, a compromise was effected, and in 1922 the 6,740-ton minelaying cruiser *Adventure* was laid down, with a speed of twenty-eight knots and a load of 280 mines.¹ A novel feature was the installation of diesel as well as steam propulsion, the former being intended to increase the endurance at cruising speed. This ship had a long and honoured career, but she was a hybrid, and proved in the event to be too large and too slow for laying in enemy waters (Plate III (a)).

As the years passed, however, the need to strike a proper balance in the composition of the fleet began to be appreciated, and opinion swung slowly in favour of the building of minelayers designed as such, together with the provision of material for the conversion of suitable war vessels should the necessity arise. It will therefore be more convenient to deal with each type of minelayer under the appropriate heading and in the chronological order in which they were authorized.

Submarine Minelayers

The potential value of the submarine as a minelayer had been recognized before 1914 and during World War I the building of submarine minelayers had been actively canvassed, but turned down in favour of the adapted patrol class submarine. The arguments in favour of a good mine, with the obvious corollary of a submarine capable of carrying and laying it in adequate numbers were, however, overwhelming, and in 1930 the *Porpoise* was laid down, followed in succeeding years by the *Narwhal*, *Grampus*, *Seal*, *Rorqual*, and *Cachalot* (Plate III (b)).

¹ Unless otherwise stated, mine-carrying capacity is hereafter expressed in terms of the number of *broad-gauge* units carried. In ships capable of carrying both types, the number of narrow-gauge units capable of embarkation was larger, in the rough proportion of 1.2 to 1.

These ships, of 1,500 tons surface displacement, were designed to carry fifty Mark XVI mines in a non-watertight casing outside the pressure hull. This arrangement called for the production of special minelaying gear, and as this gear was also installed in later surface minelayers, it would be well to describe here the standard method previously employed in surface ships. In this earlier method (Fig. 39), the train of

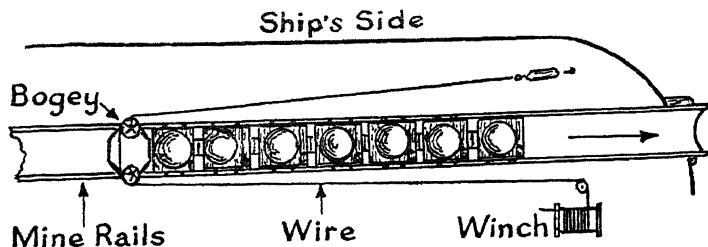


FIG. 39. 'WIRE AND BOGIE' METHOD OF LAYING MINES

mines was pushed aft by means of a bogie, which was in effect a dummy sinker fitted with a large horizontal sheave or pulley block. A wire rope, secured by a spring buffer at the after end of the mining deck, was led forward round the bogie sheave and brought aft again to a power driven bollard or winch. Thus by hauling on the wire the train of mines was moved slowly aft, the mine nearest the stern being man-handled into a trap, from which it was released at the correct moment. The latter was indicated by a McKaffery-Klyne clock, on which was set the speed of the ship and the distance apart at which it was desired to lay the mines. If the minelayer was proceeding at a moderately high speed, the time interval between the laying of two successive mines was short. For example, at a speed of 12 knots, with mines spaced at 120 feet, the interval would be six *seconds*. It was therefore the normal practice to lay mines alternately from the sets of rails fitted on either side of the ship, thereby doubling the time interval for each set of rails. The method was simple, but called for a large number of well-trained men to tend the wires, winches, and bogies and to ensure that everything ran clear, and it was in any case inapplicable to submarine laying.

An entirely new mechanical system, known as the 'chain conveyor', was therefore evolved for use in both submarine and surface minelayers (Fig. 40). This system might with some justice be said to have been based on a combination of the toy train coupling and the mountain rack-railway. The sinkers of the mines are connected together by means of simple pin and socket couplings, while right aft in the ship a short length of endless chain is fitted in a pit beneath the mine rails. This chain, equipped with three lugs, is moved by power through a variable-ratio drive, and as the lugs take in turn against the bottom of the sinkers, the train of mines is *hauled* aft, as opposed to being pushed. As each mine reaches the downward curving after end of the rails it tilts and the

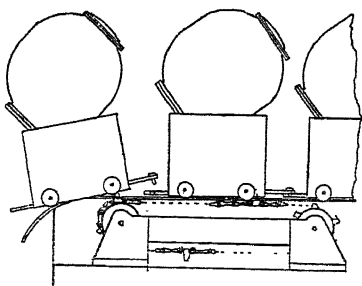


FIG. 40. 'CHAIN CONVEYOR'
METHOD OF LAYING MINES

coupling pin automatically disengages, allowing the mine to enter the water without manhandling or the use of a trap. The time interval for laying is indicated by the movement of a pointer on an instrument which resolves the speed of the ship and the required spacing, while another pointer is driven off the chain conveyor gear itself. All that is required to maintain the correct spacing is to keep the speed of the chain conveyor so adjusted that the two pointers remain in line. In the case of submarines, the reading from a small taut-wire measuring apparatus is fed into the laying indicator, which then resolves the distance travelled by the submarine 'over the ground' and the required spacing between the mines.

The use of this system not only results in a saving in manpower, but is more accurate and less liable to hang-up than the wire and bogie method. In a surface minelayer, it enables mines to be laid at speeds up to twenty knots. There is, however, no great advantage in laying at very high speeds of ship. For example, a ship laying 180 mines spaced 150 feet apart will take nine minutes longer to do it at fifteen knots than she will at twenty knots. That is to say, she will be in enemy waters

for nine minutes longer than she need have been, a very small proportion of the total time required for the operation as a whole. But at the higher speed the chances of detection due to increased bow wave and wake are increased, together with the chances of material failure or human error. The primary object of high speed is to enable the layer to evade detection on the way to and from the laying area, while should she be brought to action and wish to get rid of her mines the mechanical laying gear enables her to do so with the utmost rapidity.

Destroyer Minelayers

It will be recalled that a certain number of destroyers of the V and W classes had been equipped for minelaying in World War I, but had not actually been employed as minelayers. It should be noted that the expression 'equipped for minelaying' means that the necessary structural alterations are made and the mine rails fitted, but the full gun and torpedo armament is retained. When required for minelaying, a proportion of the armament is disembarked to compensate for the weight of the mines, and the minelaying gear is fully rigged. A more correct description would therefore be 'equipped for rapid *conversion*' to minelaying duties, and the requirement that the conversion should be capable of being carried out in forty-eight hours has always been met with ease. Reversion to full destroyer status is even more rapid, and has on occasion been completed in five hours.

The V and W destroyers referred to above formed part of the post-1918 fleet, and between the wars they were periodically converted for minelaying exercises. They could, however, only lay narrow-gauge mines, and this in fact applied to all destroyers then in existence or projected, as there was not sufficient clearance past the after superstructure to enable larger mines to be used. For some years the argument prevailed that no Commander-in-Chief would be willing to divert new ships to minelaying duties, and that ability to convert destroyers for this purpose should therefore be confined to obsolescent vessels. Against this it was pointed out that an obsolescent ship must by definition have been new at some period of her

existence, and that it is therefore more economical and satisfactory to make the necessary structural alterations before rather than after she is completed, particularly as they do not interfere with the exercise of her proper functions. The latter point of view, which the present writer at the time thought was correct, eventually won the day, and it was decided to *build* the destroyers *Esk* and *Express* to be capable of conversion to carry sixty mines each with laying by both chain conveyor and wire and bogie. Subsequently, a similar decision was taken with regard to the twenty-four destroyers comprising the G, H, and I classes. Arrangements were also made to enable certain older destroyers of the S and T classes, forming the Hong Kong and Singapore Local Defence Flotillas, to lay forty mines each by hand.

The Fast Minelayers

The *Abdiel* and the converted destroyers had done a first-class job in World War I, but as time went on and informed opinion on the potentialities of minelaying in enemy waters crystallized, it became correspondingly evident that our resources for this purpose should be built round a nucleus of craft designed to fulfil it in the most effective manner. The natural reluctance, noted in the Preface, to devote money to the building of specialized ships of this type having been overcome, there emerged the 2,650-ton fast minelayers *Abdiel* and *Latona*, authorized in the 1938 programme (Plate III (c)), and followed by the *Manxman* and the *Welshman*. These successful little ships, with a designed speed of thirty-nine knots, a load of 160 mines, a good radius of action, an adequate gun armament, and a reasonably small silhouette, were to perform excellent service, and were much sought after as commands. They were fitted with chain conveyor laying, with wire and bogie laying as a standby, taut wire measuring gear carrying 120 miles of wire, paravanes, and the most up-to-date navigational and radar equipment.

Their sole disadvantage from the point of view of those engaged in the planning of minelaying operations turned out to be their extreme suitability for doing something else, such as the carriage of special stores and troops.

Barrage and Coastal Minelayers

As already noted, arrangements were made to earmark the necessary gear for the conversion of merchant vessels should the need arise. The wire and bogie method was adhered to, partly on the score of simplicity and the small amount of structural alteration involved in its fitting as compared with the chain conveyor, and partly because the latter would not be sufficiently powerful to haul the larger number of mines carried in converted merchant ships.

It was originally planned to take up two ships of the Bank Line in the event of war, but in fact only one, the *Teviot Bank*, was immediately available in 1939, with a capacity of 280 mines. The *Princess Victoria*, a car ferry operated by the L.M.S. Railway, was therefore substituted for the second Bank ship. She had a speed of nineteen knots and carried 244 mines, and her internal layout made the work of conversion extremely simple (Plate IV (b)).

For the special purpose of laying the Dover Barrage in 1939, as described in the next chapter, the two Southern Railway train ferries *Hampton* and *Shepperton* were also earmarked for conversion and the necessary gear laid aside before the war. They carried 270 mines.

In addition, the *Plover*, of 805 tons, was laid down in 1936. She was designed to carry out minelaying trials in peacetime and was fitted with special recovery devices and facilities for recording and analysing trial lays. Under these conditions, she could carry eighty mines, this number being increased to 100 when the trial equipment was landed and she was converted to her alternative role of coastal minelayer. This ship proved invaluable in peacetime and performed remarkable service in war (Plate IV (a)).

Coastal Force Craft as Minelayers

The value of motor torpedo boats for minelaying operations in inshore enemy waters had been demonstrated off the Belgian coast. As craft of this type did not again have any place in the British Navy until shortly before World War II, it was not possible to pursue the matter further, but it was generally recognized that the provision of minelaying gear

would present no difficulty, and in the event this proved to be the case.

Controlled Minelayers

An essential feature in implementing the plans for the defence of various harbours was the provision of craft for laying controlled loop minefields, and, as we have seen, this type of work very definitely called for vessels designed, built, and equipped for the purpose. These either took the form of mining lighters, distinguished by numbers and not by names, or of small loop minelayers. Three of the latter, all capable of proceeding abroad, were completed in 1938 and 1939, and named *Redstart*, *Ringdove*, and *Linnet*.

Minelaying Aircraft

The idea of using aircraft to lay mines had been considered at Dover towards the end of World War I, but nothing had come of it. The magnetic ground mine developed between the wars had originally been conceived as a weapon to be used by torpedo-carrying aircraft, and its shape and size was initially governed by the requirement that it should be capable of being carried in and released from the standard torpedo crutches. Thus on the outbreak of World War II the only aircraft strictly available to lay these mines were the Swordfish of the Royal Navy and the Beauforts of the Royal Air Force. In the light of subsequent events, it was fortunate that they were suitable for carriage in the bomb-racks of the long-range bombers without other than minor alterations either to the aircraft or to the mines themselves. It had, however, been impracticable in peace-time to investigate in any detail the problems of release from the greater height and at the greater speed inevitably associated with the employment of long-range bombers.

The supreme value of aircraft, and their influence on the development of the British offensive minelaying campaign in 1939-45, are dealt with later.

Production and Supply

To implement the war plans and to allow for an extension of minelaying activities as the war progressed, it was decided

that a world stock of 20,000 mines would be adequate, backed by a production and supply organization capable of working up to an output of 10,000 mines per month after six months of war.

A yearly peace-time production of 500 mines was authorized, the new mines as they came forward replacing an equivalent number of the obsolescent H.II type. In conjunction with the general development of mines and their components, the system of associated firms was exploited with success. Under this system, the firm to whom the contract for ultimate production had been awarded was, if possible, brought in at the design stage, thereby enabling the best use to be made of their available tools and equipment, and in many cases evoking valuable suggestions with regard to materials and details of assembly.

The question of storage and supply was examined by a Committee set up for the purpose in 1930. Their approach to the matter was eminently logical in that they first endeavoured to establish the *number* of mines likely to be required in a future war, and *where* they would be required, before proceeding to the purely technical problem of how they should be stored, maintained, prepared, and issued. In other words, they began by making what was in effect an appreciation of the place of mines in future naval warfare.

Apart from the acute lack of storage space experienced in World War I, it had been found necessary on many occasions to use ships fitted as mine-carriers for direct supply to the minelayers, particularly abroad. The Committee's views on the probable future requirements, although proved in the event to be more or less clairvoyant, were not at the time universally accepted, and in any case the need for economy once again had a powerful influence on the extent to which their recommendations could be implemented. Their detailed examination of the factors affecting the safe storage, transit, and handling of explosives were, however, of the utmost value when the time came to give effect to such of their recommendations as were accepted.

In brief, the position on the outbreak of World War II was that a large mine depot had been established at Frater,

near Gosport, with smaller depots at Milford Haven and at Wrabness, near Harwich. There was an embarkation depot at Immingham, and special arrangements had been made at Dover in preparation for laying the barrage. In addition to the varying amount of storage space available at these places, a certain amount of bulk storage was also in existence in different parts of the country. Abroad, mine depots had been or were in course of being completed at Malta, Haifa, Trincomali, Singapore, Hong Kong, and in Australia, with storage facilities at Kilindini, Durban, and Freetown.

With regard to the actual preparation of the mines for laying, as opposed to their assembly, it had previously been the practice for this to be done in full by the minelayers themselves. This policy was reversed, and the preparation of the mines and their examination after transit, e.g. assembly at Frater and examination and embarkation at Immingham, became the responsibility of the depot organization, manned by civilian personnel under the Director of Armament Supply at the Admiralty. Work on board the minelayers was thus confined to carrying out the final functioning tests, setting the required depth, making the necessary adjustments to flooders clocks and delayed release mechanisms, &c., if fitted, and inserting the primers and detonators. Under this scheme, fewer skilled ratings were required in the minelayers, work in the depots was more rationally spaced, and the turn-round between successive operations was reduced to the time required to embark the mines, refuel, and afford the necessary rest and relaxation to the crews. The latter is a point of importance, experience having shown that the continued operation of minelaying forces for more than a given period inevitably leads to serious mistakes, if not to actual disaster.

To revert to the question of storage, it is difficult if not impossible to do more than provide reservoirs which serve to take up the slack due to the inevitable fluctuations in expenditure and supply. The latter can not be turned on and off like a tap, and the planner is therefore under continual pressure to make long-dated forecasts of his requirements for the benefit of the supply departments. Pure crystal-gazing is of little avail, and a forecast to be of any value must be based

on the form-book, as every gambler knows. In time of war, this publication is, unfortunately, partly written in a code to which the enemy alone holds the key, and to this extent the problem of storage is insoluble.

In connexion with controlled mining, special depots were established to meet the planned defence requirements for the principal bases at home and abroad. To meet the needs of the mobile organization for the temporary defence of a base, the S.S. *Atreus* was taken up in peace and converted to be capable of carrying the necessary mines, cable, control station, ancillary stores, and boats.

A general summary of the position at the outbreak of war in 1939 will be found at the beginning of the next chapter, but it will be apparent that, in spite of certain perfectly human errors of judgement and the effect of financial stringency, the position was incomparably better than it had been in August 1914.

CHAPTER VII

WORLD WAR II

(The Campaign in British Waters)

As stated at the beginning of this book, it is thought best to refer chiefly to British activities when dealing with more recent events, in order that we may have a clear picture on which to base our future attitude to this type of warfare. In an unofficial account, it is, moreover, impracticable to describe in detail the events of 1939-45, and for present purposes it is unnecessary. The object of the two previous chapters was to catalogue the nature and extent of the experience gained in war and to enumerate the steps subsequently taken to profit by that experience. It is intended in this chapter to review the measures adopted in the Second World War to apply the lessons learnt and to assess the value of the results achieved.

The resources available to Great Britain at the outbreak of World War II may be summarized as follows:

Mines. Reliable moored contact mines on broad-gauge plummet and hydrostatic type sinkers were available for laying from surface craft and submarine minelayers. Moored magnetic mines, for laying from surface craft only, were also in production.

These mines could be laid in depths of water up to 1,000 fathoms, and at depths below the surface up to 303 feet, according to the type of sinker in use. Detachable charge cases containing 500 lb. or 320 lb. of T.N.T. were provided, the minimum spacing between adjacent mines being 150 feet, or forty mines to the mile, when using the large charge, and 120 feet, or fifty mines to the mile, when using the small one.

Ground magnetic mines for laying by torpedo-carrying aircraft were about to come into production, with an explosive charge of approximately 800 lb. of T.N.T.

World stocks were of the order of 20,000 mines of all types, a proportion being the obsolescent H.II moored contact

variety on narrow-gauge sinkers. The existence of both broad- and narrow-gauge sinkers, although operationally unhandy, was not an overwhelming drawback, as the majority of the available minelayers were fitted with broad-gauge rails and so could carry and lay narrow-gauge sinkers by shipping a third rail. The V and W class destroyers, fitted with narrow-gauge rails only, were not in fact employed as minelayers.

Anti-sweeping devices, such as evaders, snags, and delayed release sinkers, were available, and the effective lives of all contact mines could be accurately restricted by fitting flooders worked by electric clocks.

A large amount of controlled mining material and the necessary vessels for laying the loops was in readiness.

Minelayers

Immediately available *and loaded*:

<i>Adventure</i>	Cruiser minelayer
<i>Express</i> and <i>Esk</i> . . .	Destroyer minelayers
<i>Plover</i>	Coastal minelayer

Available:

<i>Porpoise, Seal, Grampus,</i> <i>Rorqual, Cachalot and Nar-</i> <i>whal</i>	Submarine minelayers
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Under conversion:

<i>Hampton</i> and <i>Shepperton</i> .	Train ferries
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Available or shortly available for conversion:

8 Destroyers of the S and T classes	
14 Destroyers of the V and W classes	
24 Destroyers of the G and H and I classes	
<i>Teviot Bank</i>	Merchant ship
<i>Princess Victoria</i>	Car ferry

Building:

<i>Abdiel, Latona, Manxman</i> and <i>Welshman</i>	Fast minelayers
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Countermeasures. For dealing with moored mines there was the nucleus of a force of fleet and auxiliary minesweepers in

commission. The organization for the calling up of trained reserves, for the installation of equipment in auxiliary mine-sweeping craft, and for the commissioning of reserve fleet minesweepers was in motion. All H.M. ships down to and including cruisers were fitted with paravanes, and the material was ready for the equipment of merchant vessels with the appropriate version of this type of self-protection. Certain fleet destroyers were fitted with the two-speed destroyer sweep.

For dealing with non-contact ground mines, only the cruder forms of sweep had been tried out, but considerable information was available on the self-protection of ships against this form of attack.

Plans for the establishment and marking of swept channels and for the promulgation of mine warnings were cut and dried, and known to all concerned.

Minelaying Policy and Plans

While it had been appreciated that the object of an individual minefield might be to endanger a particular type of enemy ship, the object of the British minelaying campaign was conceived on broader lines: 'To contribute to the protection of the sea communications of the Empire by the destruction or threat of destruction of the naval forces of the enemy, and to assist to the maximum possible extent in the dislocation of his war effort'.

To achieve this object, a twofold policy had been outlined: on the one hand, the laying of large protective minefields in our own waters, as the situation might require, and, on the other hand, the persistent laying of small fields in enemy waters. The pre-war plans to implement this policy comprised the laying of a barrage across the Straits of Dover, the laying of a small field between the Bass Rock and the North Berwick coast, and the laying of a series of fields in the Heligoland Bight. The installation of controlled loop minefields for the defence of the principal harbours at home and abroad had been planned in detail, and in the case of Hong Kong and Singapore fields of independent moored contact mines also formed part of the planned local defences.

As the war progressed, proposals for the laying of mines

came from various sources. Normally, they were formulated at the Admiralty to meet the general strategic situation, or were put forward by Commanders-in-Chief to meet the particular situation in their own commands. Frequently, however, they came from other ministries, and in particular from the Ministry of Economic Warfare, to whose strangulatory processes the laying of mines was well attuned.

Proposals were also received from members of the general public, and this, of course, occurs in peace as well as in war. While it is rare for such proposals to be of direct operational value in themselves, they are without exception examined with the greatest care, as they may and often do embody an idea which it is worth while exploiting in some other way.

With this general background, it is proposed to deal with the operations in our own waters in this chapter, and with those in enemy waters in the following chapter, and it may assist the reader to refer to the maps at the end of the book which show the areas in which British mines were laid throughout the world.

Minelaying in British Waters

The honour of laying the first mine of the war fell to the *Plover*, who on the afternoon of 3 September 1939 began the Bass Rock minefield. She completed the field on the following day and proceeded to Dover to take her part in the laying of the Cross-Channel Barrage.

The Dover Barrage

It had for several years been clear that in the event of war with Germany the defence of the English Channel would be of vital importance, both for the safe passage and maintenance of an expeditionary force and for the protection of convoys in the western approaches. A plan for the laying of deep and shallow mines across the Straits of Dover, and deep anti-U-boat fields in the Folkestone-Gris Nez area was therefore worked out in detail many months before the war and all material and supply preparations made. The essence of the plan was speed of execution, particularly in the laying of the deep and shallow lines between the Goodwin Sands and the

Dyck Shoal. The ships earmarked to take part were the *Adventure*, the *Plover*, and the two train ferries, *Hampton* and *Shepperton*. During the precautionary period, the two latter ships had in fact been taken up, and were in an advanced stage of conversion when the war broke out. It was thus possible to begin laying on 11 September 1939, and the Goodwins-Dyck Barrage, totalling 3,000 mines, was laid in five days, an effort which reflected considerable credit on the officers and men concerned. The mines used both here and in Folkestone-Gris Nez fields were of the H.II type laid in the same area in 1918, with, where necessary, the special sinkers produced at that time for the purpose. As before, fixed moorings had to be used, which involved a survey of the area and the laying of special beacons to guide the minelayers. Concurrently with the declaration of war, the necessary mine warnings had been issued in accordance with international law, and the French authorities co-operated by laying further minefields off Dunkirk.

The laying of the deep fields in the Folkestone-Gris Nez area was then progressed steadily, though rather more sedately, by the *Hampton* and *Shepperton*, but it seems clear that the enemy was surprised by the speed of the original operation. It must have been obvious to German naval officers that some form of barrage would be laid across the Straits, but they presumably did not expect us to make any preparations for doing so until after the outbreak of war. No attempt was made by the enemy to interfere with the laying, and two U-boats were mined and sunk in October. A third got into difficulties and broke up on the Goodwin Sands after being depth-charged by local anti-submarine patrols. From then onwards the enemy appears to have made no attempt to pass U-boats through the Straits in any numbers, but it is not easy to establish whether this was entirely due to the barrage or to a change in the strategic situation. There can be little doubt that the barrage did justify its existence, although the fall of France defeated the purpose for which it had originally been laid. After that event the Goodwins-Dyck line was reinforced from time to time, but as an anti-ship rather than as an anti-submarine measure.

Meanwhile, the enemy had not been inactive, and by November it had become clear that he was using some form of non-contact mine, an event which gave rise to three widely accepted fallacies. The first of these fallacies was that the Germans invented the magnetic mine, and this we have seen to be untrue. The second was that Great Britain was taken by surprise, and the third that once a German mine had been recovered a party of scientists worked through the night to unravel its mysteries, the Admiralty wound a few coils of wire round every ship in the world, and the job was done. This unconscious tribute to an institution seldom associated in the public mind with rapidity of motion was no doubt gratifying, but in fairness to all concerned it would be well to view the matter in its proper perspective.

As noted in the previous chapter, we knew a great deal about the magnetic conditions in the vicinity of ships, but the expenditure in peacetime of large sums of money based on a pure guess as to the type of mine to be used by a potential enemy was out of the question. Even had such a step been acceptable, *and* the guess been correct, it would have been impossible to make the necessary bulk preparations without the fact becoming known. It would then have been a simple matter for the effectiveness of those preparations to be offset by a modification to the design of the mines.

The German magnetic mine, as first used, did in fact work on an increase in the vertical component of the magnetic field. The unit for measuring the intensity of a magnetic field is the gauss, or one line of force per square centimetre, and the magnitude of the intensities dealt with in mine warfare is such that the milli-gauss (m.g.), or one thousandth of a gauss, is a convenient sub-unit. The German mine fired if subjected to a field of 50 m.g. for a minimum period of five seconds. As the average total vertical magnetization for ships in the waters round the British Isles is of the order of 90 m.g. this was a useful setting, as it more or less ensured that the mine would only be actuated when right under a ship.

On the other hand, the relative coarseness of the setting made the reduction of the field below 50 m.g. possible by a comparatively crude system of degaussing—that is, by winding

a current-bearing coil round a ship so as to give her less North-Pole down polarity.

It therefore seems fair to say that the rapidity with which ships were provided with protection against the first German magnetic mine was attributable to four main factors. First, to the work of those who accumulated the necessary data in peacetime and under conditions of rigid national economy; secondly, to the gallantry of those who recovered and stripped the mine which fell in the mud off Shoeburyness on 22 November 1939; thirdly, to the skill of those who evaluated the information so obtained in terms of the equipment required for the self-protection of ships; and, finally, to the effort made by the electrical engineering industry of Great Britain in providing that equipment with rapidity and making available the necessary experts to assist the Royal Navy in its installation. The whole affair, in short, was a matter of inspired team-work.

The German mine was undoubtedly a beautiful piece of work in design, material, and workmanship, but it had certain technical limitations. In the first place, as we have seen, it had to be adjusted to balance the earth's magnetic field for the area in which it was to be laid, and this adjustment had to be made *during manufacture*. If, for example, it was decided to lay a group of mines off the Humber which had originally been intended for laying in Scapa Flow, it was necessary for them to be returned to the factory for readjustment. It seems probable that faulty organization resulted in mines being laid with the incorrect adjustment, thus causing premature firing and hence some of the unexplained explosions off the east coast of England.

Secondly, the dip needle and its associated mechanism was extremely susceptible to shock, and so a large parachute of some 12 feet in diameter was required to reduce the speed of entry into the water to about 75 feet per second. This slow descent made the mines easier to spot by coast-watchers, and also served to accentuate any inaccuracy in laying, thereby increasing the chances of recovery and examination.

In addition to these technical shortcomings, the first German magnetic mines were grossly mishandled from the operational point of view. On the outbreak of war, the enemy possessed

about 100 of this type out of a total stock of some 20,000. Due to jealousy and lack of co-operation between the Navy and the Luftwaffe, these were expended in a premature and haphazard manner, while the high command was quite satisfied that it would take us at least two years to discover the antidote. They had therefore made no plans for development, and the magnetic mine fell into disrepute. It is believed that the subsequent success of the British minelaying campaign caused a revival of interest and support, but by then valuable time had been lost and we were fully organized to deal with any new developments.

It should not, however, be inferred that the enemy did nothing whatever to improve his mines. As a first step, an ingenious method was introduced whereby the mine itself measured the intensity of the earth's magnetic field for the area in which it was laid, and automatically applied the necessary correction. This enabled a more sensitive setting to be used, of the order of 20 m.g., later reduced to 15 m.g., and finally to 5 m.g. by the end of 1941. This reduction in sensitivity cut both ways, however, as it made the mines easier to sweep in a manner to be described later. Concurrently with the introduction of automatic latitude correction, the enemy produced a dip needle operating on a *decrease* as opposed to an *increase* in the vertical field. This did not make the mine any more difficult to sweep, but it complicated the degaussing problem. The comparatively crude methods originally installed to meet the immediate menace had simply been directed to reducing the North-Pole-down properties of ships, and in many cases this had been overdone to the extent of actually reversing the polarity and producing a South-Pole-down ship. The German innovation was designed to take advantage of this fact, and it imposed on us the necessity to reduce the magnetization of ships to a minimum. By this time, however, we were well placed to do so. Not only had the technical requirements been worked out, but stations had been or were being established all over the world to measure the magnetic characteristics of every ship as she left harbour and to inform her forthwith of the settings to be made to the various current-bearing coils.

In addition to the degaussing of ships by the fitting of coils and girdles, two other methods were used: flashing and wiping. The former involved passing a very heavy current through a large coil placed temporarily round a ship in such a way as to turn her into a permanent magnet with the South Pole down. She then retained this polarity to a sufficient extent to compensate for the normal North-Pole-down magnetization, but only for a limited time ranging from one to six months. The coil and current-generating apparatus, devised by the French, was, moreover, expensive, and this method had only a limited application. Wiping achieved the same result in a rather simpler way, a single electric cable carrying a current of 2,000 or 3,000 amperes being hauled by means of ropes up the ship's side. This could be done very quickly and different parts of the ship could be dealt with separately. Many hundreds of small vessels were so treated, while a similar process known as deperming was used for larger ships, enabling the final degaussing to be carried out with greater accuracy.

Degaussing, however, could not provide complete immunity, particularly in shallow water, and the problem remained of sweeping the mines in order to maintain clear channels for the passage of ships. In theory, the problem was comparatively simple, as the obvious requirement was to produce a strong magnetic field at a safe distance from the minesweeper. In practice, the evolution of a sweep which could be effectively handled at sea proved to be a tough proposition, and many schemes were tried out. One of the first of these was the 'mine-destroyer' ship, a fairly large vessel fitted with a colossal electromagnet in the bows. The *Borde* and several similar ships were successful in detonating magnetic mines, but not always at a safe distance, and both the hulls and the crews were subjected to severe shock. The method was, moreover, an uneconomical use of available tonnage, and was abandoned. Another type of sweep consisted of a standard 'A' sweep (i.e. a wire towed between two ships) fitted with wooden floats and having large bar magnets attached to it at intervals by hemp tails. Although such a sweep could and did detonate the German mine, the title bestowed on it of the 'Bosn's Nightmare' adequately described its shortcomings.

from the handling point of view. The next method evolved was the towed raft or 'skid', on which was mounted a large solenoid supplied with current from the towing ship, thus creating a strong magnetic field beneath the skid. Although of considerable value in rivers and restricted channels, this method had the disadvantage that the successful sweeping of a mine frequently resulted in the destruction of the skid. Now, the simplest thing to tow astern of a ship is a single length of cable, and attention was therefore directed to the production of a towed current-bearing cable. The cable had to be buoyant, in order to prevent damage due to dragging on the bottom or fouling wrecks, moorings, &c. Attempts to handle and tow a cable supported by wooden spars having reduced some of the most competent seamen to a state of incoherence, an impasse was reached, it being thought that America, not then in the war, was alone capable of producing a buoyant cable. On being approached, however, two British cable companies promptly undertook to produce the required article and there emerged the 'L' sweep.

This sweep consisted of two buoyant cables, one 175 yards long and one 750 yards long, with an electrode at the end of each. A current generated in the towing ship, and passing through the cables and the water, produced a magnetic field around the tow. The great disadvantage of this scheme lay in the fact that the distance between the electrodes called for the *continuous* passage of a current of the order of 3,000 amperes, a task beyond the capacity of a small minesweeper. The magnetic path swept was also narrow, and this was overcome by operating two minesweepers together and so more than doubling the area swept by a single ship (Fig. 41). The problem of the continuous high current was eventually solved in a most ingenious way by pulsing the current, or passing it for a very short interval. Each pulse created a sufficient field to detonate all the mines lying within an area of about 10 acres, the succeeding pulse being made just as the ends of the longer cables were passing out of the area swept in the previous pulse. German mines of either polarity could be swept by reversing the current or by an exchange in the positions of the two minesweepers.

A small number of Wellington aircraft were also used for sweeping magnetic mines, being fitted with a large coil energized by a petrol-driven generator. This method could only be used in comparatively shallow water, and also had the disadvantage that it was difficult to know the precise area

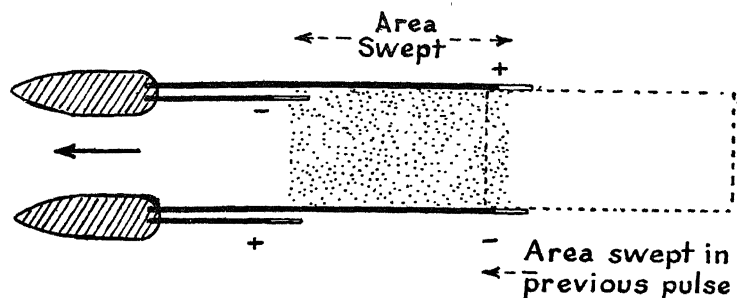


FIG. 41. THE 'LL' MAGNETIC SWEEP

covered by the sweep. It was, however, of value in narrow waters, such as the Suez Canal.

The problems set by the German magnetic mine and the steps taken to solve them have been dealt with at some length, partly to serve as a measure of the difficulties with which they themselves were to be faced, but chiefly as a tribute to the skill, the drive, and the seamanship of those who achieved one of the most notable victories of the war.

By 15 November 1939, the enemy had extended his mine-laying activities sufficiently for Great Britain to feel justified in issuing the following Notice to Mariners:

Owing to the indiscriminate laying of mines off the English coast by Germany, certain channels have been established to ensure as far as possible the safety of Allied and neutral shipping. The instructions for safe passage can be obtained at the following ports: Aberdeen, Blyth, Dundee, Methil, Leith, Harwich, Hull, Kirkwall, London, Southend, Middlesbrough, Ramsgate, Sunderland, Avonmouth, Newcastle, Barry, Belfast, Cardiff, Glasgow, Falmouth, Liverpool, Milford Haven, Newport, Plymouth, Portsmouth, Southampton, Weymouth, and Swansea.

The next move of any note in home waters was the laying of the East Coast Barrage.

The East Coast Barrage

The laying of an extensive system of minefields for the protection of traffic off the east coasts of England and Scotland proceeded in three stages. On 27 November 1939, an area dangerous due to mines was declared off the Yorkshire coast between latitudes $55^{\circ} 00' N.$ and $53^{\circ} 50' N.$ in which laying was begun by the destroyer minelayers. Concurrently the *Adventure* laid a deep field in the traffic route off Flamborough Head, but outside the area, the object being to trap U-boats who avoided the declared danger and made Flamborough Head to fix their position. On 2 December a further area was declared off the Galloper Shoal, covering the Thames Estuary, and lays carried out by the *Hampton*.

The foregoing were all anti-U-boat measures, but some apprehension began to be felt about the activities of enemy surface minelayers and the possibility of tip-and-run raids against the coast and shipping. On the 23 December, therefore, the full area from Rattray Head to the Thames was declared to be dangerous (see map at end of book). Obviously, such a large expanse of water could not be mined with a stroke of the pen, and so it was decided to lay a line of dummy mines right down the centre of the area as rapidly as possible. These mines were set to appear on the surface at half-tide, it being hoped that they would be sighted and reported by enemy reconnaissance aircraft and also by neutral fishing vessels, ever prone to risk the danger of mines rather than abandon a lucrative fishing ground. Dummy mines were used in order to avoid the necessity for sweeping when the laying of the actual minefields began, and the operation was carried out in two stages by the *Princess Victoria* in bitter Christmas weather.

The activities of the German minelayers ceased, and although it cannot be stated with certainty that this was cause and effect, there seems little reason to assume that it was what has been described as a fortuitous concatenation of apparently unrelated events.

The avoidance of this area by traffic had the effect of creating artificial focal points off the northern and southern extremities, and initial operations were confined to the laying by the *Princess Victoria*, the destroyers, and the *Hampton* of

deep anti-U-boat trap minefields outside the area and in the vicinity of these focal points. Standard contact mines were used in all cases, and a skimming sweep passed to ensure that no mines were at a depth dangerous to shipping. Laying in the area proper was begun in May 1940, and steadily progressed by the *Teviot Bank*, the *Princess Victoria*, the *Plover*, and the minelaying destroyers, with several operations later by the large minelayers taken up for laying the Orkneys-Iceland minefields, to be described, and the fast minelayers. After the German invasion of Holland, the modern Dutch minelayer *Willem van der Zaan* also joined in, after being fitted with British broad-gauge mine rails. This efficient and extremely valuable little ship was similar in design to the *Plover*, with whom she carried out some well-concerted operations both off the east coast and in the Straits of Dover before proceeding to the East Indies in December 1940. She was to return later to assist in the laying of deep anti-U-boat fields in the Channel.

As the war developed, the character of the East Coast Barrage changed to meet the menace of surface attack, U-boat attack, and invasion, and both deep and shallow contact, magnetic, and antenna mines were laid. In so far as defence against heavy surface craft and U-boats were concerned, it proved successful, although it must be remembered that the waters at the southern end of the area were in any case unsuited to the operations of U-boats under modern conditions. In so far as attack by E-boats was concerned, the barrage was by deliberate intent not made effective against light surface craft, it being decided that the freedom of movement of our own Coastal Force craft and Air-Sea Rescue service was of more importance. Secret channels for the passage of our own destroyers and heavier ships were also left, their position and direction being changed from time to time.

The Orkneys-Faroes-Iceland Minefields

An appreciation had been made before the war of the requirements for laying a mine barrage between Scotland and Norway, in case such a step should prove necessary. In October 1939, it was decided to go ahead, and a Rear-Admiral was

appointed with a staff to draw up the detailed plans, to select and organize the conversion of the minelayers, to establish a minelaying base, and to arrange for the production and supply of the mines. That Great Britain should undertake to repeat the performance of 1918 without the aid of the United States was simply a measure of the growing U-boat menace, and it was felt that any additional obstacle placed in their path was worth the effort. Even with the increased effectiveness expected to result from the maintenance of air patrols over the minefields, however, it should be emphasized that the latter were regarded as a *partial deterrent* and not as a *barrier*.

The pre-war appreciation had recommended the new moored magnetic mines in preference to the antenna type, but once again the saving in the numbers required was held to outweigh the inherent disadvantages of the latter, which was therefore adopted.

Five merchant ships were taken up and converted:

<i>Southern Prince</i>	.	10,917 tons	.	560 mines
<i>Port Napier</i>	.	5,936 tons	.	550 mines
<i>Port Quebec</i>	.	5,936 tons	.	550 mines
<i>Agamemnon</i>	.	7,593 tons	.	530 mines
<i>Menestheus</i>	.	7,494 tons	.	410 mines
Total	.	.	.	2,600 mines

Owing to the threat of air attack it was thought best to establish a base on the west coast of Scotland, and Kyle of Loch Alsh was selected. The dormant design of British antenna system was brought up to date and trials put in hand, the estimated requirement in the first instance being for 60,000 mines to be laid in five or six months. As this additional production could not be undertaken by the existing resources, the work was allocated to Messrs. Pressed Steel Co., Briggs Motor Bodies, and Wolseley Motors. These three firms were tooled up to manufacture both the mines and the sinkers by mass-production methods, and the complete units, after passing through a special depot where the charge cases were inserted, were railed to Loch Alsh, the last part of the journey from Inverness being over the line which had carried American

mines in the reverse direction in 1918. The mines were to be held in lighters at Kyle or in railway sidings at Longtown until required for embarkation, the examination after transit being carried out in the minelayers themselves.

The German invasion of Norway, which occurred when these preparations were halfway to completion, caused the original scheme to be abandoned, and the possibility was examined of laying the mines between the Orkneys and Iceland. The conditions in this area were found to be incomparably worse than those between Scotland and Norway; the front to be covered, nearly 500 miles, was almost twice as long; depths of water up to 500 fathoms could not be avoided; the current was in places more than twice as strong; and heavy seas were common for a great part of the year. There were, in fact, some parts of the area in which it was physically impossible to endanger a surfaced U-boat by means of an antenna or a contact mine of the normal type.

It was, however, decided to carry on, and fresh plans were drawn up, it being realized that the 60,000 mines originally ordered could only be used to provide anything approaching an adequate density by laying them all at the same depth. These mines, of which the first examples were known as the Mark XX, carried lower antennae 80 feet long and were also fitted with switch-horn firing, and it was decided to go for the shallower band of depths first by laying at 10 feet below low water. This figure was chosen to avoid the adverse effects of heavy seas.

In June 1940 the minelayers were formed into the First Minelaying Squadron, and the Rear-Admiral who had been charged with the planning and execution of the operations hoisted his flag in the *Southern Prince* (Plate IV (c)). The Squadron was later joined by the *Adventure*, whose anti-aircraft armament frequently enabled the services of an escorting cruiser to be dispensed with. In July 1940 a dangerous area, embracing all the waters between Scotland and Iceland and between Iceland and Greenland, was declared in very broad terms, with instructions for the safe passage of vessels through the Pentland Firth or through the Faroe Islands. Laying began.

As in 1918, trouble was experienced due to premature firing, and while the causes were being investigated a number of mines were laid with the antenna system 'sterilized', i.e. they were laid as simple contact mines.

It soon became evident that the rate of laying as originally planned could not be maintained. This was in part due to the difficulty in providing cruiser and destroyer escorts for the minelayers, and in part because the system of transit direct from the factories to the ships, although necessary in the circumstances, involved a longer period than had been estimated for the examination and preparation of the mines after they had been embarked.

On 27 November 1940, the strength of the Squadron was reduced by the loss of the *Port Napier*, accidentally destroyed by fire at Kyle of Loch Alsh. Although she had a full load of mines on board at the time, the primers and detonators had not been fitted, and there were no casualties. The slower rate of laying meant in effect that by the time the end of the line had been reached, the mines first laid would be coming to the end of their endurance. In actual fact, no attempt was made to start at one end and work steadily through to the other, the policy adopted being to lay first in those parts of the area considered most likely to be traversed by U-boats. In the meantime, arrangements were made to continue production of the mines beyond the original figure of 60,000 and various improvements were made to the mines themselves. Amongst other devices tried was the fitting of an upper antenna of which a considerable part floated on the surface, the object being to make them dangerous to surfaced U-boats at all states of the tide.

The system of minefields was also extended into the Denmark Straits in order to narrow the passage between the west coast of Iceland and the Greenland ice-pack. Moored magnetic mines were laid in this part of the area, as they could be set deep enough to avoid being carried away by ice-floes in winter while still remaining effective against surface ships. It is believed that the presence of these mines on the one hand and of the ice off Greenland on the other so narrowed the channel available for the passage of the *Bismarck* that her

sighting by cruiser patrols prior to her destruction by ships of the Home Fleet was made more certain.

Laying proceeded until January 1943, when it was decided to abandon the barrage principle and to lay deep fields of moored magnetic mines in the routes thought most likely to be followed at that time by U-boats. By then both surface and air patrols, lacking in the earlier years, were becoming available to exploit the presence of such minefields.

As in the case of the Northern Barrage of 1918, the efficacy of the Orkneys-Iceland minefields will no doubt be debated. The opinion has been expressed that had the material not been available the project would not have been undertaken. It may therefore be of interest to record the views of the late Admiral of the Fleet Sir Dudley Pound, the First Sea Lord at the time, as conveyed personally to the author. He considered that if the ships and the material had not been available, the greatest pressure would have been brought upon the Admiralty to make them available, and that the Admiralty would never have been forgiven had they failed to make the attempt to mine these waters. He also emphasized that the minefields, in addition to being no more than a hazard to U-boats, were intended to have a restrictive influence on the operation of enemy heavy surface vessels against shipping in the Atlantic. This they undoubtedly did, as well as acting as a flanking protection to the Iceland convoys.

Several U-boats were in fact sunk in the area, and in attempting to strike a balance between the effort expended and the results achieved it should be remembered that this was a *system of minefields* laid in a large area of deep water, and not a barrage in the accepted sense of the term. Whatever the answer may be, there can be no doubt that the skill, patience, and endurance of the officers and men concerned was of no mean order.

In this and other areas, the First Minelaying Squadron, exclusive of the *Adventure*, laid a total of over 110,000 mines, the *Port Quebec* topping the 33,000 mark, and on no occasion were they deterred by bad weather.

The St. George's Channel Minefields

Initially designed as an anti-invasion measure, a series of minefields was laid in August 1940 between the Cornish coast and the territorial waters of Eire. The first operation was carried out by the First Minelaying Squadron, laying contact mines, and the series was carried on by the *Adventure* and later by the *Plover*. As in the case of the East Coast Barrage, the character of these minefields was modified as the war progressed and lines of deep anti-U-boat mines were also laid. To meet the extensive requirements for deep mines in this and other areas, to be described later, a small spherical switch-horn mine known as the Mark XIX was produced, with a charge of 100 lb. of explosive. This was considered more than adequate to destroy a U-boat or to force her to the surface, and the mine was specifically designed for rapid manufacture.

Further Enemy Activities

By the end of 1940, the enemy had introduced two new devices into his mines. The first was the clicker, whereby the mine would explode only after being actuated a number of times which could be adjusted, before laying, between one and sixteen, and the second was an arming delay whereby the mine could be prevented from coming alive until after a pre-set time had elapsed. The effect of both these devices was to complicate the sweeping procedure, but neither called for new equipment. The latter, however, had to be produced to deal with the German acoustic mine which they began to lay in the closing months of 1940. The actuating mechanism comprised a simple carbon granule microphone, and although some initial successes were achieved the enemy was once again guilty of using a fresh weapon in penny numbers. We already knew a great deal about the subject and expected to be confronted with an acoustic mine sooner or later. The remedy, which consisted of fitting an electrically driven hammer in the bows of ships, and the towing of noise-making contrivances by minesweepers, was once again comparatively simple in itself, but added a further and burdensome complication. Later, in the combined magnetic-acoustic unit, the enemy

set our minesweeping service a pretty problem, but by then the general technique for the rapid design and application of countermeasures was more than highly developed. In this mine, the magnetic unit did not function unless cocked by a propeller noise of the correct intensity.

The Deep Anti-U-boat Minefields

Three large systems of deep anti-U-boat minefields were laid in addition to the smaller fields to which reference has been made. The first of these was under or in the vicinity of the shipping routes in the north-western approaches to the Irish Sea, and consisted of antenna mines laid by the First Minelaying Squadron in 1940. As on a similar occasion in 1918 when mines were laid in this area by the U.S.S. *Baltimore*, the effectiveness of these minefields is difficult to judge, as the subsequent transfer of U-boat activities to the Atlantic may well have been due to other causes.

The second large system of deep minefields was laid to the north of Cape Wrath, the object being to cover the routes followed by shipping when avoiding the area declared dangerous between the Orkneys and the Faroes. The mines were all of the small Mark XIX moored contact type and were laid by the ships of the First Minelaying Squadron working from Loch Alsh, assisted from time to time by one of the fast minelayers.

The third system was laid by the *Plover* and the *Van der Zaan* between Portsmouth and Cherbourg in the closing stages of the war, and at the same time smaller groups of deep mines were laid in the approaches to the Irish Sea by fast minelayers working from Milford Haven. The object of these fields was to assist the mobile anti-submarine forces to deal with the inshore activities of U-boats fitted with the *Schnorkel*.

Other small deep minefields were also laid as the situation required—for example, in the channel through the Faroe Islands left for the passage of shipping from Scandinavia to the Atlantic and vice versa, in the Straits of Bab el Mandeb (laid by the *Teviot Bank*), and in the shipping routes passing through the St. George's Channel minefields.

Other Protective Minelaying Operations

It is impracticable to describe in detail the controlled minefields laid for the protection of harbours, but it goes without saying that they represented a considerable effort. In the majority of cases, the loop system was used, but various types of magnetic ground mine with the firing circuit under control from the shore were also laid.

In the early days of the war, small minefields were also laid by the *Plover* in the approaches to the Clyde and off Inchkeith in the Firth of Forth. These were intended as a temporary measure pending the laying of the controlled mine defences and were swept up as soon as they were no longer required. The minefields planned for the defence of Singapore and Hong Kong were also laid early in the war by the local defence destroyers.

In the second half of 1941, these ships laid further minefields in the vicinity of Singapore, assisted by the *Teviot Bank*, who had by then joined the Eastern Fleet.

The Australian minelayer *Bungaree* also laid a number of minefields in Australian, New Zealand, and New Guinea waters. The mines were of the Mark XIV Herz horn type, and were manufactured in Australia. The operations were carried out with a high degree of accuracy, while mine-clearance operations after the war showed, by the number of effective mines remaining in many of the fields, that the standard of material and workmanship had been of the best.

Summary

Not counting controlled mines, over 185,000 British mines were laid for protective purposes in all theatres of war in 340 separate operations. Although several enemy surface vessels and U-boats were sunk as a result, the effectiveness of these minefields must be judged chiefly by the degree of protection afforded to shipping, and this was in many cases the sole reward for many months of slogging and unspectacular effort by the minelayers in the face of all sorts of weather and the not infrequent attentions of enemy U-boats and aircraft. In addition to the loss of the *Princess Victoria* by mine, the *Adventure* was mined twice, the *Southern Prince* was damaged by torpedo, and the *Menestheus* was bombed.

CHAPTER VIII

WORLD WAR II

(The Campaign in Enemy Waters)

IN itself, minelaying in enemy waters was also an unspectacular type of operation, and the hazards need no emphasis.

In the campaign of 1939-45, three distinct but closely related battles developed. First, that fought by the minelayers and the minelaying aircraft in getting to the appointed areas and laying their mines with accuracy; secondly, the material battle fought by the scientists and engineers in keeping one step ahead of the enemy minesweeping organization; and, lastly, the operational battle in which the planners strove to stretch the enemy to the limit of his physical, mental, and material endurance.

The British object was to endanger enemy ships wherever they might be legally attacked and to cause the maximum dislocation to the enemy war machine. It would therefore be well to summarize at the outset the methods adopted to achieve this object, and to elaborate on those methods when dealing with the actual operations:

(a) By spreading the minelaying effort over as wide an area as possible. Every territorial success gained by the axis powers meant an increase in the extent of 'enemy' coastal waters, and so made them more and more vulnerable to minelaying attack.

(b) By the laying of minefields consisting of several different types of mines, thus complicating the enemy's minesweeping problem.

(c) By the use of such devices as delayed arming, delayed release sinkers, and 'period delay mechanisms'—the British version of the clicker.

(d) By turning the enemy minesweeping technique to our own advantage.

(e) By the employment of various *ruses de guerre*.

Plans had been made before the war for the laying of a series of small fields along the probable enemy routes in the Heligoland Bight. By 'probable' it is meant that the Germans were expected to use the same routes as in 1918, and as far as can be ascertained they did do so.

On the outbreak of war the destroyers *Express* and *Esk* were loaded and ready, and a large area in the Bight was declared dangerous. The enemy responded rather neatly by declaring a rectangular area which straddled the western boundary of the British area. This raised the nice point of whether we should be legally justified in laying mines *outside* our area, but *inside* theirs. Operations began as soon as the state of the moon served, the destroyers working from Immingham. They were shortly joined by the *Ivanhoe*, *Icarus*, *Intrepid*, and *Impulsive* to form the 20th Flotilla, the name being chosen in view of its sentimental associations with the destroyer minelayers of World War I. These ships were all fitted with paravanes and with taut-wire measuring gear.

Early in 1940 it was decided to take the drastic step of laying mines within the limits of Norwegian territorial waters. The configuration of this coastline is such that the greater part of the passage between Narvik and Stavanger (some 500 miles) can be made in the sheltered waters of the Inner Leads, a series of channels running inside an almost continuous chain of off-shore islands. Through the Inner Leads passed the vital iron-ore traffic to Germany, emerging into the open sea at three points only.

If this traffic could be forced further to seaward by means of minefields, it would be open to search and capture outside Norwegian territorial waters. The inconvenience caused to innocent traffic would be small, and careful arrangement of the mined areas would enable fishing craft and local vessels to move in safety and allow free access to Norwegian ports.

It was therefore decided to lay mines off Stadtlandet, Bud, and in the Vestfjord. Concurrently, the Norwegian Government were to be informed, and a statement was to be issued by the Foreign Office setting out the extenuating circumstances. The present writer was associated in the composition

of this document, which is of sufficient historic interest to be quoted in full:

1. In recent weeks the German campaign against the merchant shipping of all nations has been intensified and pursued with even greater brutality than before. The number of neutral ships destroyed by German action is now well over 150, and the number of neutral lives lost is nearly 1,000.

These attacks have been carried out in almost every case in defiance of the recognized rules of war, frequently in circumstances of the greatest barbarity, and on many occasions without the slightest justification for interference of any sort with the ship.

Germany has announced that she regards herself as entitled to destroy any neutral ship *en route* to any British port, including contraband control harbours, and there have, moreover, been repeated cases of vessels being destroyed on voyage between two neutral ports, when the vessel had no intention of touching at a British port at all. It is obvious that the German Government are engaged in an indiscriminate campaign of destruction throughout the waters in which their unnotified mines are laid, or in which their submarines are in a position to operate.

2. While in recent weeks the greatest losses have fallen upon neutral shipping, British and Allied vessels have also suffered from the adoption of this policy of destruction, a new development of which is the bombing from the air of British and neutral trawlers and fishing boats and the machine-gunning of their crews.

The innocent character of fishing boats has hitherto been universally recognized, but this has not prevented Germany from committing nearly 200 attacks on fishing vessels, aimed at sinking them and murdering their crews. Even lightships, the object of which is to protect shipping of all nations and which are by international usage treated as non-combatants, have been, with their crews, ruthlessly attacked by bombs.

3. It is a fact deserving of constant emphasis that these German attacks have been deliberately aimed at the destruction of neutral lives and property; and it is abundantly clear that the purpose behind them is pure terrorism.

The Allies, on the other hand, have never destroyed nor injured a single neutral ship or taken a single neutral life. On the contrary, they have not only saved the lives of many innocent victims of these German outrages, but they have also not failed to rescue from drowning German airmen and submarine crews who have been guilty of the inhumanities in question.

4. The position is therefore that Germany is flagrantly violating neutral rights in order to damage the Allied countries, while insisting upon the strictest observance of rules of neutrality whenever such observance would provide some advantage to herself.

International law has always recognized the right of a belligerent, when its enemy has systematically resorted to illegal practices, to take action appropriate to the situation created by the illegalities of the enemy. Such action, even though not lawful in ordinary circumstances, becomes, and is generally recognised to become, lawful in view of the other belligerent's violation of law.

The Allied Governments therefore hold themselves entitled to take such action as they may deem proper in the present circumstances.

5. The Allied Governments have observed that a heavy proportion of the losses inflicted upon neutral countries both of human life and in material has fallen upon the Norwegian Mercantile Marine.

Yet while the German Government repeatedly sink Norwegian shipping and murder Norwegian seamen, they continue to demand from the Norwegian Government the fullest use of Norwegian territorial waters for their own commerce, and the Norwegian Government have even felt obliged to provide armed escort in these waters for German ships, while unable to take effective action against German brutality on the high seas, of which their own vessels have been the victims.

6. Whatever may be the actual policy which the Norwegian Government, by German threats and pressure, are compelled to follow, the Allied Governments can no longer afford to acquiesce in the present state of affairs by which Germany obtains resources vital to her prosecution of the war, and obtains from Norway facilities which place the Allies at a dangerous disadvantage.

They have therefore already given notice to the Norwegian Government that they reserve the right to take such measures as they may think necessary to hinder or prevent Germany from obtaining in Norway resources or facilities which, for the purpose of the war, would be to her advantage or to the disadvantage of the Allies.

If the successful prosecution of the war now requires them to take such measures, world opinion will not be slow to realize both the necessity under which they are constrained to act and the purpose of their action. Their purpose in this war is to establish principles which the smaller States of Europe would themselves

wish to see prevail and upon which the very existence of those States ultimately depends.

The Allies, of course, will never follow the German example of brutal violence, and any action they decide to take will always be carried out in accordance with the dictates of humanity.

7. His Majesty's Government in the United Kingdom and the French Government have accordingly resolved to deny the continued use by the enemy of stretches of territorial waters which are clearly of particular value to him, and they have therefore decided to prevent unhindered passage of vessels carrying contraband of war through Norwegian territorial waters.

They accordingly hereby give notice that the following areas of Norwegian territorial waters have been rendered dangerous to navigation on account of mines. Vessels entering these areas will do so at their peril.

Stadtlandet. An area enclosed by the Norwegian coast and lines joining the following positions:

- (i) $62^{\circ} 11' 06''$ N. $5^{\circ} 06' 12''$ E.
- (ii) $62^{\circ} 09' 24''$ N. $5^{\circ} 00' 13''$ E.
- (iii) $62^{\circ} 12' 18''$ N. $4^{\circ} 49' 30''$ E.
- (iv) $62^{\circ} 19' 30''$ N. $5^{\circ} 05' 36''$ E.
- (v) $02^{\circ} 12' 00''$ N. $5^{\circ} 09' 00''$ E.

Bud. An area enclosed by the Norwegian coast and lines joining the following positions:

- (i) $62^{\circ} 58' 27''$ N. $7^{\circ} 05' 30''$ E.
- (ii) $63^{\circ} 03' 30''$ N. $6^{\circ} 54' 00''$ E.
- (iii) $63^{\circ} 07' 12''$ N. $7^{\circ} 04' 30''$ E.
- (iv) $62^{\circ} 59' 24''$ N. $7^{\circ} 07' 15''$ E.

Vestfjord. An area enclosed by the Norwegian coast and lines joining the following positions:

- (i) $67^{\circ} 24' 40''$ N. $14^{\circ} 34' 00''$ E.
- (ii) $67^{\circ} 27' 30''$ N. $14^{\circ} 24' 00''$ E.
- (iii) $67^{\circ} 28' 55''$ N. $14^{\circ} 06' 45''$ E.
- (iv) $67^{\circ} 33' 55''$ N. $13^{\circ} 51' 30''$ E.
- (v) $67^{\circ} 37' 55''$ N. $14^{\circ} 02' 15''$ E.
- (vi) $67^{\circ} 26' 20''$ N. $14^{\circ} 38' 30''$ E.

It will be observed that the laying of mines in these waters will in no way interfere with the free access of Norwegian nationals or ships to their own ports and coastal hamlets.

In order to avoid the least possibility of Norwegian or other

vessels inadvertently entering these areas before there has been time to give warning of the mines being laid, arrangements have been made for the limits of the areas to be patrolled by British naval vessels until a period of 48 hours has elapsed from the laying of the first mine in each area. This measure, in conjunction with the broadcast warning, should fully provide for the safety of shipping.

The date fixed for the operation was 8 April 1940. It was decided to invoke the 'military exigencies' clause of the Eighth Hague Convention on account of the difficulty of predicting the conditions off the Norwegian coast with any accuracy. It would have been most undesirable to issue the warning statement on the assumption that everything had gone according to plan, only to find that the minelaying had in fact been postponed due to bad weather. The most elaborate arrangements were therefore made to inform the Admiralty that the first mine had been laid, and to pass this information on to our Legation in Oslo.

In the event, the first mine entered the water at 4.30 a.m. The Admiralty had the news by 4.45 a.m. and the warning statement was broadcast on the Empire wavelengths at 5 a.m. and again on the seven o'clock Home Service, being subsequently repeated in sixteen different languages on the foreign wavelengths.

It had naturally been expected that both Norway and Sweden would protest against this violation of neutral rights, at least as a matter of form, but the violence of the language in which these protests were couched exceeded all forecasts. World opinion as a whole accepted the position with calm, but certain difficulties with regard to the future status of neutrals were foreseen in some quarters. By a strange coincidence, however, the preliminary moves in the German occupation of Norway coincided with the laying of the mines. On the day following the operation Oslo was in German hands and Norwegian waters had ceased to be neutral. The code-word 'Wilfrid' was, by direction of Mr. Winston Churchill, allocated to this operation, and in a statement published in the Press, the Germans saw fit to praise its technical excellence.

In the meantime, plans had been maturing for the laying of ground magnetic mines by aircraft, it having been very

properly decided that we should hold our hands until adequate stocks were available and production in full swing. It will be recalled that the British A. Mark I magnetic mine had been designed for laying by torpedo-carrying aircraft, and it became clear at an early stage that it would be impracticable to operate aircraft-carriers in the southern part of the North Sea, which ruled out naval aircraft. The torpedo-carrying Beauforts of Coastal Command could reach the German North Sea ports and estuaries, but for operations further afield the long-range bombers of Bomber Command would come into their own. This meant adapting the mines for laying from greater heights and at greater speeds, which was accomplished by substituting a small parachute for the original ballistic tail, a step which also had the advantage of reducing the overall length of the mine and so easing the problem of stowage in the bomb racks (Plate V (a)).

All was ready by the night of 13/14 April 1940, and on that night the first British aircraft mines were laid by Hampdens of No. 5 Group Bomber Command in the Great Belt, the Little Belt, and the Sound. Two nights later Beauforts of Coastal Command joined in, laying mines off the Jade River. Both types of aircraft carried one mine each. At the same time a large area was declared dangerous in the Baltic, care being taken to respect the limits of Swedish territorial waters. Operations were rapidly extended within this area, and also to Oslo and positions off the German North Sea estuaries, such as the Ems and the Weser, all of which were covered by the dangerous area originally declared in the Heligoland Bight. This latter area was also enlarged to embrace the whole of the Danish coast, the Kattegat, the Skagerrak, and all Norwegian waters, a channel thirty miles wide being left to give access to the North Sea from Swedish waters.

The destroyers, reinforced by the submarine *Narwhal*, continued laying in the difficult waters off the Norwegian coast and in the Inner Leads, and the submarine *Seal* carried out the ill-fated sortie into the Kattegat in which she was captured by the enemy on 4 May 1940.

The German incursion into Holland on 10 May 1940 was notable for a gallant effort by the *Princess Victoria*. Against such

an event, plans were in existence for the laying of a minefield off the Dutch coast to afford some additional cover for escaping ships. The intention had been for this to be done by the 20th Destroyer Flotilla, but in case they were not available the *Princess Victoria* had been acquainted with the plan. As it turned out, the destroyers were at the time on their way back from an operation in the Heligoland Bight. At 6.30 a.m. on 10 May the Commanding Officer of the *Princess Victoria* was therefore asked by telephone from the Admiralty whether he was all ready. He replied that he could get away within the hour, taking with him the corvettes *Widgeon*, *Puffin*, and *Shearwater* as escort. This he proceeded to do, and on orders from the Admiralty the escort was taken over by the *Express*, *Intrepid*, and *Esk* off the entrance to the Humber. During the forenoon the *Princess Victoria* reported her intended movements, and that she expected to begin laying at 9.15 p.m. This information was passed out by the Admiralty to all ships and authorities concerned, and also to the British Naval Attaché at the Hague, so that the Dutch coastal batteries could be warned. She laid her first mine at 9.07 p.m. and the whole force returned to Immingham without incident, arriving at 9.30 on the following morning. Exactly one week later, the *Princess Victoria* was mined and sunk off the Humber with the loss of four officers, including her Captain, and thirty-three men. In her short but useful career she had laid 2,756 mines in twelve operations.

The whole of the waters off the Dutch coast were now opened up for minelaying, and with the shorter distances from the United Kingdom shore-based Swordfish aircraft of the Royal Navy were able to take part. By the end of June 1940 aircraft of the R.A.F. were laying mines from the Scheldt in the west to Lubeck in the east, and successful operations had been carried out in Oslo Harbour, in Kharm Sound (between Karmö Island and the Norwegian coast), and in the Kiel Canal. The destroyers had also laid mines off the Dutch coast, and the submarines, reinforced by the *Porpoise* and the *Rubis*, had carried on in Norwegian waters. The *Rubis* was a French submarine, carrying thirty-two moored mines of the Vickers T.III type, and was to have a long and successful career.

In the Mediterranean, the submarines *Grampus* and *Rorqual* had begun laying mines in Italian and Sicilian waters, the former being lost on about 24 June 1940.

With the fall of France, aircraft were able to extend their operations from Dunkirk to the Gironde, and off Oran the first carrier-borne aircraft minelaying operation in history was brought off by naval aircraft, who later laid mines off Sicilian and Tripolitanian ports. Further areas had been opened up in the Baltic, and in December of 1940 the Kiel Canal was again mined by No. 5 Group Bomber Command. Three months earlier, however, on the night of 31 August/1 September, destroyers of the 20th Flotilla had encountered an enemy minefield off the Texel, suffering the loss of the *Ivanhoe* and the *Esk*. The *Express*, although severely damaged, succeeded in returning to Immingham. Thus were the events of 1918 repeated, and it is a fair assumption that the activities of the flotilla in the Heligoland Bight had driven the enemy to take retaliatory measures. The submarine *Narwhal* had also been lost in August 1940 while on passage to Norwegian waters. She had laid a total of 450 mines.

In the early part of 1941, aircraft of the R.A.F. Middle East Command came into the picture in the Mediterranean, and the same period saw the start of minelaying by Coastal Force craft off the Belgian and French coasts. These craft, who operated from Dover, and later from bases in the Nore Command as well, were fitted with echo-sounding gear and with miniature sets of taut-wire measuring gear, and, according to the type of boat, could lay either ground mines or standard moored mines (Plate V (b)). Officers and men of the Royal Norwegian Navy and later of the Royal Canadian Navy took a prominent part in these operations.

In April 1941 the surviving destroyers of the 20th Flotilla returned to Fleet duties. They had done excellent work in laying nearly 7,000 mines in various areas and had also played a notable part in the second battle of Narvik and in the evacuation of troops from Dunkirk. During the year the four fast minelayers came into service. The first to commission, *Abdiel*, distinguished herself by laying mines in enemy waters before she had completed her acceptance trials, a remarkable tribute,

not only to the design and construction of the ship, but to her crew as well, 60 per cent. of whom had never been to sea before. The mere fact that she left the Clyde at five o'clock one morning and reached Plymouth just over twenty-four hours later, having embarked her mines at Milford Haven on the way, showed that a new era had dawned in the operation of offensive minelaying forces. Having steamed 3,000 miles in ten days, the *Abdiel* was given a short overhaul and proceeded to Gibraltar and Malta with special stores and passengers. She then became involved in various similar enterprises in the Eastern Mediterranean, and by the end of the year had carried some 5,000 tons of stores and 19,000 men. After one minelaying operation in Greek waters, she proceeded on the last day of 1941 to join the Eastern Fleet, and, following the entry of Japan into the war, she laid mines off the Andaman Islands.

The *Latona*, the second of these ships to commission, was never employed as a minelayer. Immediately on commissioning she sailed for the Mediterranean, and did valuable work in the conveyance of some 4,000 troops and special stores to Tobruk, being finally bombed and sunk in October 1941.

Manxman, the next of the fast minelayers, carried out two 'scalded cat' runs to Malta, and then returned to Kyle of Loch Alsh to settle down in her proper role. In the meantime, however, Admiral Sir James Somerville, holding the Western Mediterranean in command of Force 'H', had conceived the idea of disguising the *Manxman* as a French cruiser in order to lay a minefield off Leghorn. At that period of the war, the whole of these waters were dominated by the German and Italian air forces, and the Italian Fleet was still in being. A glance at a chart will show that no surface ship could hope to penetrate to the narrow channel between the island of Corsica and the mainland without the adoption of some stratagem, the display of skill and determination, and a reasonable allowance of good luck.

On 14 August 1941, the *Manxman* was ordered by the Admiralty to convert herself to look like the French cruiser *Leopard* in so far as was reasonably practicable. The Rear-Admiral Commanding the First Minelaying Squadron immediately

placed the full resources of the Squadron and of the base at the disposal of the Commanding Officer, and directed the author, then serving temporarily on his staff, to see that all possible assistance was given. He, the Admiral, considered that twenty-four hours would be sufficient for the ship to *become* the *Leopard*, and not merely to resemble her. Those concerned had been associated for many years in various amateur theatrical productions, and the job was entered into with relish, the 1940 edition of *Jane's Fighting Ships* being taken as a guide. It was decided in the first place to go for the more salient features: the deep 'break' of the forecastle, the distinctive funnel tops, the characteristic voice-pipe running fore and aft the ship, and finally the 'rake' of the masts and funnels and the curved stempiece and sloping stern. Fig. 42 shows

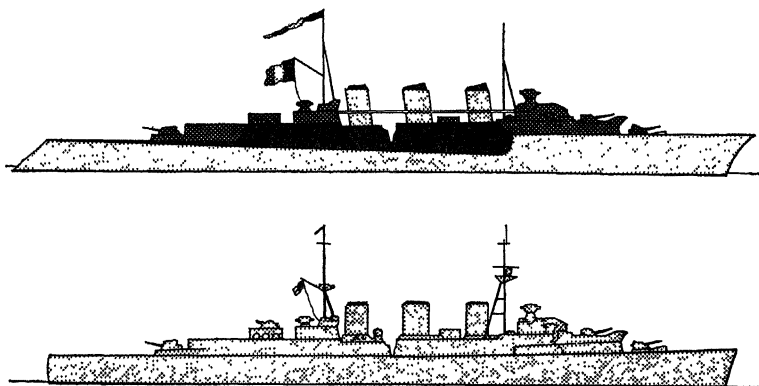


FIG. 42. H.M.S. MANXMAN DISGUISED AS A FRENCH CRUISER

the effect aimed at, and by the use of paint, canvas, and spars, it was found possible to get much nearer to the desired result than had at first been thought possible. The only real snag encountered, in fact, was the curved stem-piece. A most ambitious affair of steel, fabricated at the base, was sent off to the ship at midnight, but after much wrestling to get it to fit over the paravane gear it was discarded in favour of a canvas shape which could be hauled into place when required by means of wires, the necessary eyebolts being welded into place on the ship's side just above the waterline. In the meantime, what may be called the necessary corroborative details

were attended to, such as the French ensign and pendant, French uniforms, and so on, and in twenty-four hours almost to the minute the *Leopard* was ready for inspection by the Admiral. Leaving Loch Alsh at dusk on 16 August, the ship embarked mines at Milford Haven and proceeded to Gibraltar, keeping out of sight of land and altering course as necessary to avoid being sighted by any ships at close quarters. She arrived in Gibraltar Bay in darkness and secured alongside an oiler moored there specially for the purpose, deposited her cyphers and confidential books, picked up the detailed orders for the operation, and sailed before daylight the next morning. Passing between the Spanish coast and the Balearic islands that night, by sunrise on the following day she was fifty miles north-west of the island of Minorca with the full disguise in place, French colours flying, washing flapping in the breeze, and all those on deck displaying an air of what they hoped would pass for one of complete nonchalance. By that evening the ship was within forty miles of Toulon, still ambling along as though on passage from Oran, but, with the French Riviera coast in sight, course was altered to the eastward as though making for Ajaccio in Corsica. Immediately after dark, the false bow was furled (the original false stern, made of steel, had already dropped off on leaving Gibraltar and been replaced by a canvas structure), the paravanes were streamed, and speed increased to thirty knots. In spite of mist, the laying position was found, and the first mine went into the water at 2 a.m. under perfect conditions. The Italian mainland was visible, and the ship was sufficiently close inshore for the shaded headlights of a motor-car to be seen moving along the coast road. Laying was carried out at slow speed so as to reduce the bow wave and the wake to a minimum, and by 3.30 a.m. the last mine was in the water. The field consisted of a 'mixed bag' of moored contact, magnetic, and delayed-release mines, laid in several rows. The Commanding Officer subsequently stated that he found the next three-quarters of an hour to be the most trying part of the whole performance, as the ship had to make her way past a suspected hydrophone station on Gorgona Island, and so was forced to creep past at 10 knots. At 4.15 a.m. she was able to go on to full speed

and shortly afterwards had to alter course to avoid three ships. At daylight she *reduced* speed to thirty-three knots and then ran into thick fog, and so was able to maintain that speed until well west of Toulon. Later that afternoon, she sighted what appeared to be an actual French cruiser while off the coast of Spain. Apart from this encounter, two aircraft had passed fairly close to the ship while on the outward journey, but had apparently been satisfied that she was a French ship. The *Manxman* reached Gibraltar that night, refuelled, picked up her confidential books, and returned to Kyle of Loch Alsh.

Her Commanding Officer attributed the success of Operation Mincemeat to wonderful luck and to the diversion made by aircraft of the *Ark Royal* in dropping incendiary bombs on the cork woods at Tempio in Sardinia. The author would venture the opinion that boldness in planning and skill in execution also had something to do with it.

The *Manxman* then carried out an operation off Stadlandet in Norway and, in company with the *Welshman*, the fourth of the fast minelayers to commission, laid mines off the Brittany coast and in the Bay of Biscay. Throughout the year, operations by aircraft of the R.A.F. in European waters had gradually been extended in scope, while at Kerguelen Island in the southern Indian Ocean boats from H.M.A.S. *Australia* had laid magnetic ground mines in anticipation of the use of these waters as a base by enemy surface raiders. On 5 August 1941 the submarine *Cachalot* was lost while on a special store-carrying trip in the Mediterranean.

The highlight of early 1942 was the success achieved against the German battle-cruisers when they made their dash up the English Channel from Brest. It is popularly supposed that mines were laid ahead of these ships on the day in question in a last desperate attempt to catch them. In actual fact, they were laid some days beforehand in accordance with a plan drawn up in expectation of such a sortie. Three separate systems of minefields were laid: first, a series off the Frisian Islands by aircraft of Bomber Command. The unique feature of this operation was that it was carried out in daylight, using all possible cloud cover, in order to ensure accuracy.

Secondly, a series of fields laid by the *Manxman* and the *Welshman* off the north French coast, using moored contact, magnetic, and delayed release mines. Between them these two ships laid twelve separate minefields in fourteen consecutive nights. Thirdly, the reinforcement by the *Plover* of the central part of the original Dover Barrage, using moored magnetic mines. The latter drew first blood, one of the German destroyers proceeding *down* Channel to Brest to augment the escort available for the enemy heavy ships being sunk. The fields laid by the two fast minelayers were, of course, capable of being subjected to intense sweeping by the enemy, but nevertheless it is believed that at least one of the escorting minesweepers was sunk on the way up Channel. In the event, it was the mines laid by Bomber Command which succeeded in damaging both the *Scharnhorst* and the *Gneisenau*. Further mines were laid later the same day off the entrance to the German estuaries under extremely difficult weather conditions.

The choice of positions in which to lay the mines was a good example of the close co-ordination between the minelaying and the minesweeping staffs at the Admiralty. The advice of the latter was invaluable in narrowing down the number of alternative routes which the enemy ships might be expected to follow. Later, in the Madagascar operations, the minelaying staffs were able to return this help by forecasting with some accuracy the positions in which the enemy mines would be found.

Following on these events, the stage was set for the aircraft minelaying campaign to swing definitely in favour of the British. Until then, magnificent though the efforts of the Royal Air Force had been, they had to some extent been circumscribed by the number of aircraft available for minelaying. Technically, we had the measure of the problem, but had not made any startling innovations.

The British magnetic ground mine, as originally conceived, was of robust construction and could withstand a considerable shock on entering the water. It was independent of the polarity of the ship attacked and, as we have seen, it operated on the *rate of change* of the horizontal component of the magnetic

field and was therefore more difficult than the German type to counter by degaussing. It thus had a greater chance of success than the enemy version, but it had been realized that a change in the magnetic field would be detectable a little way ahead of the target, and in order to cause the explosion to take place beneath the hull the detonators had been fitted with a delay mechanism. The next step had been to take advantage of the fact that the magnetic signature of a ship changes its 'sign' from negative to positive and back to negative as she passes over a given spot, and a relay circuit had been devised which required contact to be made first in one direction and then in the other before the circuit was completed between the firing battery and the detonator. This improved the position of fire, rendered the mines less liable to counter-mining, and to some extent complicated the enemy's sweeping problem. In this latter connexion, although the enemy had developed an efficient type of towed-cable sweep, to deal effectively with the British mine he was also forced to use mine-destroyer ships, or *Sperrbrechers*. These craft, similar to the British 'Borde' type, suffered from the same disadvantages, and these disadvantages had been exploited by the laying in each field of a proportion of mines having such a coarse relay setting that only the powerful magnetic field generated by a *Sperrbrecher* could actuate them, and then only when beneath the ship. We thus had a mine which could distinguish between friend and at least one kind of enemy, and which caused him the loss of much valuable tonnage, thirty-one of these ships being sunk and a further seventy-seven damaged before the end of the war. For dealing with minesweeping aircraft, an instantaneous setting was used, so that the mine fired directly beneath the aircraft. This could only be effective in comparatively shallow water, as the destruction of the aircraft was brought about by the plume of water thrown up by the explosion of the mine. The sensitivity of the relays had also been improved from the original 60 micro-amp. polarized suspended coil type to a pivoted and balanced type having a sensitivity of 15 micro-amperes, later to be reduced to 5 and in special cases to 3 micro-amperes. (As the actuation of the relay depended on the induction of an electric current in the C.R.

rod, the sensitivity was measured in amperes, or rather in millionths of an ampere.)

Arming delays, and period delay mechanisms, or clickers, had also been introduced, but whereas the enemy could generally be relied on to use these devices in accordance with a set and almost predictable plan, the British procedure was more subtle. Having considered the probable nature and density of the traffic in the area to be mined, and having decided whether high, medium, or low settings were to be used, the actual settings were chosen by drawing numbers out of a hat, thereby introducing the random-chance effect which is so difficult to counter.

Finally, by switching the laying effort from one area to another, it had been found possible to spring a series of minor but recurrent surprises on the enemy minesweeping organization, which obviously could not be maintained at sufficient strength in all areas simultaneously.

Thus the initial technical advantages of the British mine, coupled with the display of a certain amount of sagacity in its use, had been exploited for rather longer than might have been expected, but it was clear that this state of affairs could not continue indefinitely. With the translation of Sir Arthur Harris from the command of No. 5 Group to the post of Commander-in-Chief, Bomber Command, the effort devoted to minelaying was stepped up. Nos. 1 and 3 Groups were brought in during March and May 1942 respectively, with aircraft of longer range and greater carrying capacity, and later in the year No. 4 Group was included. Concurrently, the organization to cope with this expansion of effort was rounded off, a Captain R.N. being appointed to Headquarters Bomber Command, with a small naval staff, and naval officers were appointed to serve on the staffs of the air officers commanding the various groups engaged in minelaying. The broad plans continued to be formulated at the Admiralty, the detailed planning and the execution of the operations resting with Bomber Command. The mines themselves were, of course, designed, produced, and supplied by the Admiralty, and naval torpedo gunner's mates were drafted to the groups to assist in their preparation for laying. From April 1942 onwards

the minelaying activities of Coastal Command were confined to attached naval aircraft.

The first major technical change was made in August 1942, when a more or less straightforward acoustic assembly was introduced. Some discussion arose at the time as to the value of such a mine, it being argued that as the Germans were already in the field with combined magnetic and acoustic circuits, they would find no difficulty in dealing with a simple acoustic version. However, the minelaying staff at the Admiralty held out for the simple version on the grounds that the enemy would never expect us to use it, and would therefore be taken unawares. This view prevailed, and on two successive nights some 500 acoustic mines were suddenly laid in as many areas as possible. The results were subsequently found to have been quite startling, and although the enemy got to grips with these mines fairly quickly after suffering heavy casualties, we were by then under way with combined magnetic-acoustic circuits. In the meantime, however, we had found a further useful variation in the application of magnetic principles. This incorporated a unit which, on the receipt of a single actuation, started a clock and put the detonator in circuit. If a second actuation was received within a period of six to sixteen seconds the mine fired; if not, then the unit returned to normal. This device was almost completely immune from countermining, and it had fairly good anti-sweeping properties. It could not, in fact, be swept at all by aircraft, as by the time the second actuation was due the aircraft would be much too far away to impart it. The British acoustic detector for picking up normal vibrations consisted of a cantilever secured at one end to a diaphragm at the rear end of the mine-shell, the free end being in electrical contact with a second lever. When the resistance between these two contacts was varied as the result of incoming vibrations, the current from a battery was diverted to a condenser in one leg of a 'bridge' circuit until sufficient potential was built up to discharge the condenser and fire the detonator. A second type, designed to pick up low-frequency vibrations, employed two flexible reeds attached to crystals of Rochelle salt. The strain on the crystals due to the vibration of the reeds caused a

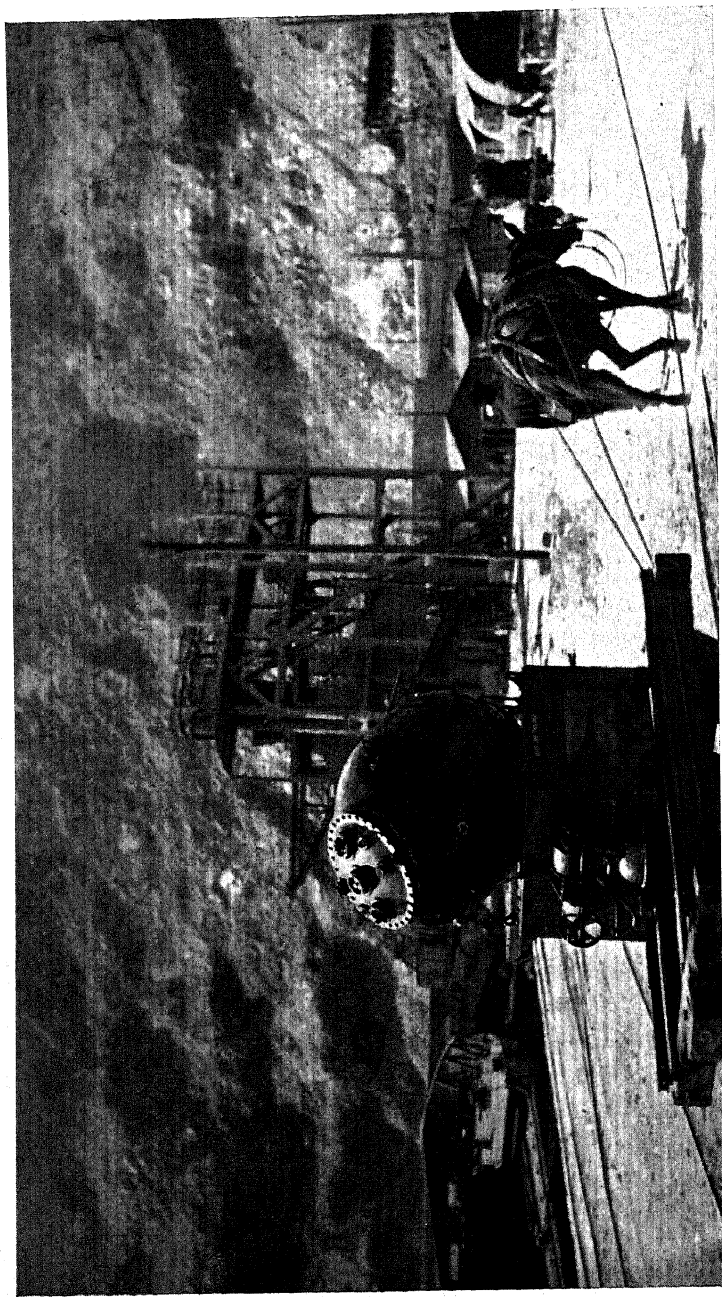
static charge to be generated, which was fed into a valve amplifier and thence to the detonator circuit.

The enemy reaction to the use of acoustic mines was similar to the British, i.e. hammer-boxes and towed noise-makers, but they also adopted the expensive method of firing numbers of small under-water explosive charges.

With regard to moored mines, the only notable British development had been the 'snag-line' mine, which consisted of a floating line attached to one of the horns of a standard contact mine. The object of this device, which the Germans copied, was to endanger small craft such as E-boats, and mines so fitted were chiefly used by Coastal Force craft for laying off the enemy bases in Holland.

By the end of 1942, then, Bomber Command were engaged in widespread operations, using a variety of different types of mine actuating units. Towards the end of the year attention was chiefly directed to the Biscay ports to assist in the protection of convoys proceeding to North Africa. Mediterranean aircraft, with the *Porpoise*, *Rorqual*, and *Manxman*, laid mines in preparation for the North African campaign, the latter ship having been recalled from the Indian Ocean, where she had relieved the *Abdiel*. On 1 December 1942 the *Manxman* was seriously damaged by torpedo while returning from an operation in the Sicilian Channel, but succeeded in reaching harbour. The *Welshman* had for some time been engaged on special transport duties.

The year 1943 was notable for the scope and the variety of the British and Allied minelaying operations in all theatres of war. In the Mediterranean, interest was centred on the landing in North Africa, the object of the minelaying operations being to dislocate the enemy line of communications. Aircraft of the R.A.F. laid mines in La Goulette and off Sfax, Trapani, Ras Kaboudia, Olbia, and Catania; the *Abdiel* and the *Welshman* in the Sicilian Channel, and the *Rorqual* in Sicilian waters. British motor torpedo boats were also adapted to lay American mines which were surplus to their defensive requirements. On 2 February 1943 the *Welshman* was torpedoed and sunk while returning from an operation. In the course of her career she had laid over 3,000 mines in twenty-two operations, and



(Lieutenant S. E. Pritchard, R.N.)

The Transport Problem

had carried out nearly thirty trips with important stores, food, ammunition, and personnel.

These minelaying operations in the Sicilian Channel presented a special supply problem, as it was a long way to Haifa, and the Mine Depot at Malta was more or less buried under a heap of rubble. A temporary depot was therefore set up at Algiers and fed by freighting assembled mine units from the United Kingdom in the *Adventure*. As will be seen from Plate VI, some local improvisation of transport was necessary. In spite of the difficulties, some forty enemy warships and transports were mined, and the enemy was forced to reorganize the sailing of his convoys in such a manner that they became more vulnerable to attack from the air.

At home, No. 6 Group Bomber Command had meanwhile been brought in. This was a Royal Canadian Air Force Group, whose skill in execution and fertility of ideas was to make a notable contribution to the minelaying offensive. On two nights in April 1943 aircraft of Bomber Command performed the remarkable feat of flying from the United Kingdom across Europe to lay mines off Spezia, while the operations of Coastal Force minelayers were extended along the whole of the Dutch, Belgian, and French coasts, and off the Channel Islands, additional flotillas being brought in to work from Portsmouth and Plymouth. The *Rubis* carried out some further useful operations in the Bay of Biscay.

In the East, minelaying in Burmese waters was begun by Liberators of the American 7th Group, based in India, using both British and American mines. Laying was gradually extended to Indo-Chinese and Chinese waters, and aircraft of the Royal Air Force subsequently joined in. In April 1945 Catalina aircraft of the Royal Australian Air Force began laying mines in the South-west Pacific area, and continued to do so with outstanding success.

Towards the end of the year, further areas in the Eastern Mediterranean were mined by aircraft of the R.A.F. and on 10 September 1943 the *Abdiel* was mined and sunk while on troop-carrying duties. She had laid over 2,000 mines and performed useful and varied service since first commissioning in March 1941. This left the *Manxman*, seriously damaged, as

the sole survivor of the four original fast minelayers, but the *Ariadne*, first repeat ship of the class, was commissioned on the day of the *Abdiel*'s loss. She proceeded to the Pacific to operate under the direction of the Admiral Commanding the United States 7th Fleet.

To revert to the technical battle, by the beginning of 1943 it had become clear that, in addition to the general programme of development, some method was required whereby new ideas could be applied with rapidity, and immediate advantage taken of any fresh intelligence about enemy sweeping technique. With the industry of the country geared to war production, it was essential that only bulk orders should be placed for new material, and this inevitably entailed some delay before that new material began to come off the production line. By that time, the purpose for which any special types of mines were required might well have passed. A separate organization, known as 'MX', was therefore set up for the rapid production by hand of small numbers of what our American colleagues so aptly described as 'tailored assemblies'. In this organization, housed at Portsmouth, a combined team of designers and naval officers worked out new circuits, which were then translated directly into material form and fitted into the afterbodies of standard mines by a group of specially trained Wrens working under their immediate supervision. The complete mines were then freighted to the selected aerodromes by the Armament Supply Department. An output of some fifty mines a week was achieved, which enabled a continual stream of variations to be superimposed on the main run of bulk production. Any one of these variations might prove to be effective for a short period, or it might be so successful as to be worth while incorporating in the long-term 'repertoire'. In this case, the design could be rationalized for bulk production, conventional manufacturing drawings prepared, and the matter dealt with in the normal way.

It may be said without exaggeration that the enemy were to regret the day in January 1943 on which this organization, whose total output was to exceed 5,000 special mines, came into being. It would be impossible to deal with the activities of the MX organization in detail, but sufficient has already

been said to make it clear that the object of the designer is to produce a mine which will either make use of the enemy's sweeping technique or one which will detect the difference between a minesweeper and a normal ship. As an example of the first type, reconnaissance showed that the enemy was in the habit of escorting important ships and U-boats in and out of harbour by means of a minesweeper stationed ahead. Careful evaluation of photographs having established the normal distances and speeds employed, a combined coarse and sensitive magnetic unit was evolved which would only fire the mine if influenced by a strong magnetic field and a normal magnetic field in the correct sequence and, within certain limits, at the correct time interval. In other words, the mine simply sneered at the minesweeper and fired under the target. If for any reason either the speed or the spacing of the minesweeper and the ship escorted lay outside the limits catered for in a particular mine, and so no fire occurred, the unit reverted to normal and waited for the next pair of victims. The enemy's first reaction to this device was to precede his U-boats by *two* minesweepers or *Sperrbrechers*, to which the MX organization responded with a unit which would let two sweepers go by. The enemy then tried *three* sweepers, and rosy visions were conjured up of the last surviving U-boat being escorted into harbour by the full strength of the German minesweeping force. Unfortunately, the space inside a mine-shell is limited, and so the method of attack had to be switched for a time.

The second general type of detecting unit depended on the fact that a minesweeper succeeds by virtue of her ability to produce magnetic or acoustic influences of abnormal intensity, whereas in an ordinary ship the magnetic and the acoustic characteristics are interrelated. These 'overlap' units, as they were called, were therefore designed to operate only when in the presence of standard ship-phenomena. Similarly, double acoustic circuits were devised which could discriminate between the noises caused by underwater explosions and the gradual build up of noise from an approaching ship.

Although a number of combinations and permutations of these various methods was possible, they were in no case

completely incapable of being dealt with in some way or another, but, by a continual study of the enemy sweeping methods and convoy formations, and by the mixture of different types of mines in each field, it was possible to maintain a high casualty rate per mine laid. And so with large numbers of Lancaster aircraft available, each capable of carrying six mines, the enemy was by the end of 1943 beginning to get into serious difficulties. The problem of casualties to our own minelaying aircraft due to the intensification of enemy defences had, moreover, been overcome by the installation of equipment which enabled mines to be laid with accuracy from a height of 15,000 feet through 10/10ths cloud.

The year 1944 saw the climax of the British minelaying offensive in all theatres of war. In northern European waters, a complex operation known as 'Maple' was carried out in connexion with the Normandy landings by aircraft of Nos. 1, 3, 4, 5 and 6 Groups Bomber Command, *Apollo*, the second of the repeat fast minelayers, *Plover*, five flotillas of motor torpedo boats (the 9th, 13th, 14th, 21st, and 64th), and four flotillas of motor launches (the 10th, 50th, 51st, and 52nd). The plan had of necessity to avoid compromise of the intended date and locality of the assault, and to ensure the freedom of movement of our own forces and military convoys. In addition to the use of delayed arming, these requirements called for the lives of the mines to be governed in certain cases with absolute accuracy. Until then it had been the practice when possible to avoid the use of clock mechanisms by fitting simple electrolytic 'sterilizers' which could be guaranteed to run the firing batteries down at some time *before* the date set, the variation in the actual date of operation being accepted. For the purpose of this operation, however, where finger-tip control was essential, clock-operated sterilizers were used in large numbers.

Laying began on 17 April, and in the seven weeks between that date and D-Day nearly 4,000 mines were laid by aircraft of Bomber Command and a further 3,000 by surface craft, an average rate of 1,000 mines per week. Two fresh types of mine unit were introduced for these operations. The first, for use in ground mines, was a low-frequency acoustic unit

which was to cause the enemy considerable trouble, being virtually impossible to sweep without specialized and heavy apparatus. The second, also an acoustic unit, was incorporated in a proportion of the moored mines. This was the first use of moored acoustic mines by either side during the war.

These operations resulted in approximately 100 enemy ships of various types being sunk or damaged, and their conclusion was marked by a letter of congratulation to all concerned from Admiral Sir Bertram Ramsay, dated 10 June 1944.

Amongst the highlights of this series was an extremely skilful and successful lay by Mosquito aircraft of Bomber Command in the Kiel Canal on the night of 12/13 May, using specially shortened standard mines assembled on the aerodrome by Wrens from the MX organization. In the previous month, Lancaster aircraft had also carried out a difficult lay in the Koenigsberg Canal, flying practically at water level.

With the development of the military situation on the Continent, opportunities for minelaying by naval forces in European waters became progressively reduced, but aircraft of Bomber Command continued their offensive against U-boats and the movement of enemy troops and stores from Norway and the Eastern front, bringing their total effort for the year to over 17,000 mines.

In the meantime, Liberator and Wellington aircraft of the Mediterranean Allied Air Forces had in May 1944 begun a comprehensive series of lays in the Danube. By October 1,200 mines had been laid in the river, accounting for over 200 ships and other craft sunk and many more damaged. Although this was the highest casualty rate per mine achieved in any area, the curious point is that the mines were of a comparatively simple type. Owing to the shape and disposition of the bomb cells in aircraft of American design, it had been found impossible to install British mines of the standard length and diameter. For this reason, and also to provide a smaller mine for laying in shallow water, there had earlier in the war been produced the A. Mark V with a total overall weight of 1,000 lb. A later and improved edition known as the Mark VII

had also been produced, as well as the still smaller Mark VIII with an overall weight of 500 lb. The missing mine in the above series, the A. Mark VI, was the 2,000-lb. edition for use in the Normandy operations. (The Marks II, III, and IV simply varied in detail from the original A. Mark I.) We thus had mines capable of being carried in the appropriate bomb racks of all British bombers, but in the case of the smaller versions, as used by American type aircraft in the Danube and in the East, there was no available space in which to fit 'clever' actuating units, and in fact they differed but little from the original pre-war design. It is understandable that the enemy minesweeping organization on the Danube might have been caught on the wrong foot in the first place, and there are certain difficulties associated with sweeping in shallow water, but their exhibition of sustained ineptitude was as welcome as it was unexpected. Other operations in the Mediterranean theatre included lays off the Italian coast by motor launches, the mines being supplied from the *Teviot Bank*, then on her way home from the Indian Ocean on conclusion of a career in which she had laid over 15,000 mines.

In the South-east Asia Command, in Chinese waters, and in the Pacific, aircraft of the R.A.F., the R.A.A.F., and the U.S.A.A.F. continued their successful series of operations, being reinforced by the *Porpoise*, the *Rorqual*, and the Royal Netherlands submarine O.19. Certain patrol submarines also used ground mines designed for laying from their torpedo tubes.

The Germans, meanwhile, had played their last card, the 'Oyster' or pressure mine. The remarkable thing about this mine is its extreme simplicity, the principle upon which it operates being well known to every canal engineer in the world and suspected by most rowing coaches. Beneath every moving ship there is in comparatively shallow water a fairly long area in which the hydrostatic pressure at the sea-bed is reduced by an amount which depends on her speed and on her draught. In the pressure mine (Fig. 43) a rubber bag exposed to the sea is connected to a space which is divided into two parts by means of a diaphragm. On laying, the pressure is equalized on either side of the diaphragm through

a leak-hole, and any slow variations of pressure due to swell are taken care of in the same way. When a ship passes over the mine, however, the sudden reduction in pressure, corresponding to a head of about 2 inches of water, cannot be dealt with quickly enough by the leak-hole. The pressure on either

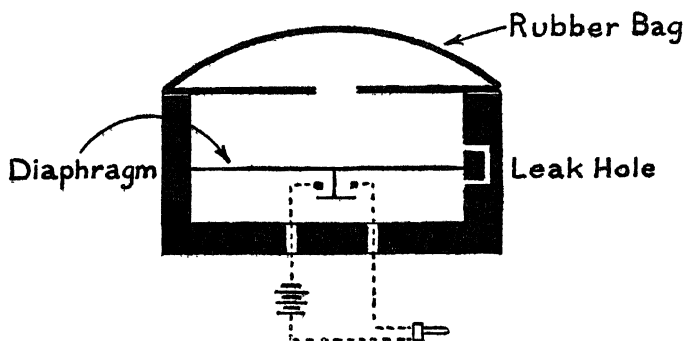


FIG. 43. THE PRESSURE OR "OYSTER" MINE

side of the diaphragm therefore becomes unbalanced, and it is sucked towards the rubber bag and so completes the firing circuit to the detonator. The difficulty in dealing with this system lies in the fact that a low-pressure period of sufficient duration to actuate it can as a general rule only be produced by an actual ship or by some body comparable in size to a ship, and to this extent the pressure mine is unsweepable. Its virulence can, in addition, be enhanced by combining it with either magnetic or acoustic systems of actuation. As in other cases, the Germans did not have a monopoly of brains in this connexion, and there had been a British pressure mine in existence for several years. In view, however, of the absolute dependence of Great Britain on the security of her communications by sea, it had for long been the policy to refrain from laying any type of mine unless we were in possession of the necessary antidote, for without such safeguard a similar mine used by the enemy could do us far more harm than we could do to him. We therefore held our hands with the pressure mine. The Germans, apparently, adopted the same policy, and it was only on the direct orders of Hitler himself that their

version was used as a last desperate measure. Once again the enemy presented us with a couple of free samples, but in any case the wealth of data already accumulated on the subject enabled the Admiralty to issue immediate instructions for the safe speeds to be adopted in various depths of water. Wave-making by groups of high-speed craft was also tried, together with the towing of large expendable structures. The heavy gales off the Normandy beaches also proved a little too much for many of the German mines, and in one way or another their effectiveness was reduced, but they retained a very considerable nuisance value.

From the beginning of 1945 to the end of the German War the story continued to be one of interference with enemy troop movements and U-boats in the Baltic and Norwegian waters, and the strangulation of Japanese sea communications in the East. Towards the end of the war some interesting carrier-borne operations were completed by naval aircraft in the Norwegian Leads. It is sometimes asked whether it was worth while to employ a fairly large force of ships to lay a comparatively small number of mines, as opposed to using shore-based bombers. The reason was that the mines were laid primarily for the purpose of driving traffic to sea, where it could be dealt with by cruisers and destroyers working with the carriers. Not only were the mining areas in the leads extremely difficult to locate, but variable weather conditions made it impracticable for Bomber Command to guarantee that they would be able to co-ordinate the laying of mines with the presence of the naval forces.

In January 1945 the *Porpoise* was lost in Eastern waters. She had laid a total of 465 mines, and this event left the *Rorqual* as the sole survivor of the original six minelaying submarines. She had laid a total of nearly 1,300 mines. April 1945 saw the *Manxman*, her torpedo damage made good, on her way to join the British Pacific Fleet with a total of over 3,000 mines and many special trips to her credit.

Summary

In all theatres over 76,000 British mines were laid in enemy waters during the war. Of these, nearly 55,000 had been laid

by aircraft,¹ 11,000 by fast minelayers and destroyers, 6,500 by Coastal Forces, and 3,000 by submarines. In the course of actual minelaying operations, one fast minelayer, two destroyers, four submarines and four Coastal Force craft had been sunk, and approximately 500 aircraft had been lost in 21,000 sorties.

Results Achieved

On 15 May 1946 it was announced by the Admiralty that as a result of British minelaying during the war, approximately 1,050 Axis warships and merchant vessels were sunk and a further 540 damaged. The detailed figures issued at the same time are shown in tabular form on p. 166. The above figures do not include the casualties inflicted on the Japanese, who are reported to have lost 266 ships to American mines and twenty-one to British mines, while a further thirty-four were lost due to 'causes unknown'.

As was to be expected, the advent of aircraft as minelayers had rendered traffic in waters nominally under enemy control far more vulnerable to minelaying attack than in 1914-18. It is not, therefore, surprising that the majority of the casualties inflicted on the enemy were due to mines laid by aircraft, and a high proportion due to those laid by Bomber Command.

It will, however, be clear that the effectiveness of different types of minelayer cannot be compared solely on the basis of casualties inflicted on the enemy, as so much depends on opportunity, on the number of minelayers employed, on the area of operations, on the type of target attacked, and on the *purpose* of particular minefields. Similarly, the true value of the campaign as a whole cannot be judged on the basis of enemy ships sunk or damaged. The indirect effects, to which reference is made later, are of considerable importance.

The Germans, in addition to the display of great ingenuity in the development of all types of mine, made the fullest use of aircraft, submarines, and E-boats as minelayers, and are believed to have laid over 120,000 mines and 30,000 obstructors

¹ The following types of aircraft were employed at one time or another: Swordfish, Beauforts, Albacores, Avengers, Hampdens, Wellingtons, Manchesters, Halifaxes, Stirlings, Lancasters, Mosquitos, Catalinas, Liberators, and Mitchells.

in the waters of north-western Europe alone. Abetted by the Italians, they laid many more in the Mediterranean. These figures are a measure of the burden imposed on the British and Allied minesweeping forces, while up to D-Day in 1944 the British degaussing organization alone had dealt with some 18,000 vessels, the maintenance of whose equipment involved the daily passage of about 500 individual ships over the degaussing ranges, and the rapid analysis and communication to them of the results.

ENEMY CASUALTIES DUE TO BRITISH MINES

Type of enemy ship	Mines laid by						Total		Grand Total
	Surface vessels		Submarines		Aircraft				
	Sunk	Dam.	Sunk	Dam.	Sunk	Dam.	Sunk	Dam.	
Battleships	—	—	—	—	—	1	—	1	1
Battle-cruisers	—	—	—	—	—	2	—	2	2
Destroyers and torpedo boats	12	3	4	1	5	5	21	9	30
Minelayers	—	—	—	—	2	—	2	—	2
Patrols escort vessels	3	8	2	3	28	39	33	50	83
U-boats	17½	—	—	1	16	13	33½ ¹	14	47½ ¹
Sperrbrechers	9	3	—	—	22	74	31	77	108
Minesweepers	8	14	3	—	50	68	61	82	143
E-boats	5	1	—	—	—	3	5	4	9
R-boats	7	9	—	—	4	2	11	11	22
Naval auxiliaries	2	2	1	—	20	16	23	18	41
Depot ships	—	—	—	—	—	1	—	1	1
Merchant vessels	38	7	34	3	342	195	414	205	619
Tankers	—	—	—	—	75	7	75	7	82
Train ferries	—	—	—	—	5	4	5	4	9
Dredgers	—	—	—	—	2	1	2	1	3
Tugs	—	—	1	—	46	6	47	6	53
Armed trawlers	3	—	7	—	11	9	21	9	30
Sailing vessels and small craft	1	—	1	—	7	—	9	—	9
Fishing vessels	7	2	—	—	30	11	37	13	50
Lighters and barges	3	—	—	—	137	4	140	4	144
Unclassified	9	1	6	—	62	22	77	23	100
Totals	124½	50	59	8	864	483	1047½	541	—
	174½		67		1347		—	—	1588½

¹ This figure includes credit for 4½ kills arising from 9 U-boats which were sunk 'by surface laid mines or other causes'.

The total number of British ships sunk by enemy mines was 577, made up of 281 warships of all types and 296 merchant vessels, while the total number of Allied merchant vessels

sunk was 521.¹ These figures are somewhat illuminating when compared with those already given for the mines laid by us in enemy waters and for the mining casualties inflicted on the enemy. It is also noteworthy that in the course of the war there were several months during which the British suffered no casualties at all. The enemy enjoyed no such immunity, although employing nearly twice as many ships and one and a half times as many men on minesweeping duties.

It would be idle to suggest that we made no mistakes, or to claim that the British mines were necessarily better than the German. But the cold fact remains that our mines defeated their minesweeping organization, while our minesweeping and degaussing organization defeated their mines. We were not merely 'swapping pawns', for the total effort expended by both sides, compared with the results, left a balance in our favour not far short of two to one.

The reasons for this happy outcome are analysed in the final chapter of this book.

¹ *Ships of the Royal Navy. Statement of Losses During the Second World War. British Merchant Ships Lost or Damaged by Enemy Action during the Second World War* (H.M. Stationery Office, 1947).

CHAPTER IX

THE MINE IN INTERNATIONAL LAW

THERE is sometimes a tendency to question the sanity of any attempt to establish rules for the conduct of war.

War, the argument runs, has always been an inhuman affair, but nowadays it involves nations as a whole, and is not confined to the armed forces of the belligerents. It is further argued that adherence to international agreements in the certain knowledge that they will be flouted by others is merely to impose unnecessary suffering on civilian populations in addition to tying the hands of the fighting men.

It would be out of place to expand here on the ethical poverty of these arguments. It is sufficient to note that if the rule of law is to be accepted, then it must be good law, and it is on this basis and this alone that the matter can be discussed with any profit.

The sole international instrument on the subject of mine warfare is the 'Convention Relative to the Laying of Automatic Submarine Contact Mines (No. VIII)', signed at the Hague in 1907.

As stated elsewhere in this book, the Russo-Japanese War saw the first use of what was then termed 'deep-sea mining', as opposed to 'defensive mining'. The results achieved were sufficiently spectacular to make it clear that this development was likely to have a profound effect both on the conduct of war at sea and on the safety of neutral shipping. The preamble to the Convention covered both these aspects of the problem, the actual wording being as follows:

Seeing that, while the existing position of affairs makes it impossible to forbid the employment of automatic submarine contact mines, it is nevertheless expedient to restrict and regulate their employment in order to mitigate the severity of war and to ensure, as far as possible, to peaceful navigation the security to which it is entitled, despite the existence of war. . . .

As in the case of many similar documents, the phrases uncoil themselves rather more smoothly in the official French version, but in any language the sentiments expressed would be altogether admirable. The approach of the individual governments, however, to the question of giving practical effect to these sentiments varied according to their geographical position, their political ambitions, and their grading as maritime Powers. The one thing they had in common was a natural inability to foretell the future in so far as technical developments in mining material were concerned.

It would be tedious to follow in detail the various proposals and counter-proposals made in committee. Each article of the *final* Convention will therefore be taken in turn, with some notes on the more important considerations leading to its adoption and a brief review of its subsequent bearing on the conduct of mine warfare.

Article I

Clause 1: It is forbidden to lay unanchored automatic contact mines unless they be so constructed as to become harmless one hour at most after those who laid them have lost control over them.

The word 'automatic' was used throughout the Convention, and it would be well to dispose of its significance at the outset. The intention was to describe the type of mine which detonated automatically if struck by any ship, be she enemy, neutral, or friend, as opposed to the type which was fired at will from the shore by means of an electric cable.

The inability of 'deep-sea' mines to discriminate between enemy and neutral was one of the main reasons for the attempt to frame international rules for their employment in war. In the case of anchored mines, neutrals could at least be warned of the dangerous areas, whereas *unanchored* mines free to drift in any direction under the influence of wind and tide represented a completely indiscriminate source of destruction.

It is not to be wondered at, therefore, that the unanchored mine took first place in the deliberations of the Committee appointed to prepare a preliminary draft Convention, or that the discussions under this head were prolonged and at times

acrimonious. Great Britain and the United States proposed to forbid the use of unanchored mines, but Italy, Russia and Japan were in favour of allowing such mines to be used, provided that they were so constructed as to become harmless at some comparatively short time after being laid. A period of one hour was suggested. The real reason for this counter-proposal was embodied in the statement of the Italian naval delegate that '... a belligerent could still use a weapon which might as a last resort, *especially where a weaker vessel was being pursued by a stronger*, prove its salvation'.

This was not an argument likely to commend itself to a major naval Power such as Great Britain. While it is true that throughout the discussions Great Britain was primarily influenced by considerations of a humanitarian nature, from the purely practical point of view she regarded the mine as a weapon of the weaker fleet, and therefore of little value to a nation having command of the sea. As noted in Chapter III, this attitude was reflected in the scant attention directed to technical development, and was largely responsible for the backward state of our mining material when war broke out in 1914.

The German delegation adopted the attitude that while it would be absolutely sound to restrict the effective lives of *anchored* mines which broke adrift from their moorings, they could not accept the application of this principle to *unanchored* mines. In their view, the proposed limit of one hour would be useless in the case of a weak naval force attempting to escape from a stronger.

The German contention was hotly attacked by Sir Ernest Satow on behalf of the British delegation. He received a considerable measure of support, and as a result the German delegation expressed their willingness to accept a ban on the use of unanchored mines for a period of five years. Commentators at the time were inclined to applaud this proposal, and to deplore the fact that it was not adopted, but in reality it had no meaning. In the first place, the Powers were engaged in a series of peace conferences, and it was therefore to be hoped that peace would in fact prevail for a period of at least five years. Secondly, and as a purely practical consideration,

to forbid the *use* of a particular weapon for a given period does not prevent a Power from engaging in the development and production of that weapon.

The proposed limitation of one hour's effective life was finally agreed, but in neither world war did the influence of unanchored mines justify the gloomy prognostications of the delegates to the Hague. Used offensively, they are extremely difficult weapons to handle with effect, and are likely to be just as much of an embarrassment to those who lay them as to those whom they are intended to attack. Used defensively (i.e. against a pursuing force), large numbers are required to achieve any sort of useful concentration, and the space they take up on board is far better used for some other purpose.

It seems fair to suggest that in adopting the first clause of Article I the delegates lost sight of their object. On the one hand, as suggested by Germany, the imposition of a one-hour limit rendered unanchored mines practically useless from an operational point of view, and, on the other hand, it failed to *ensure* the safety of peaceful navigation.

The second clause of Article I reads as follows:

It is forbidden to lay anchored automatic contact mines which do not become harmless as soon as they have broken loose from their moorings.

The use of the word 'contact' probably arose because the 'defence' mine, controlled from the shore, did not have to be struck by a ship, and was thus a 'non-contact' mine. The delegates seem to have been obsessed with the idea that the expression 'automatic contact mine' *must* be used in its entirety to distinguish the type they had in mind from the 'controlled non-contact mine'. This failure to confine themselves to 'automatic' as the operative word, without bothering their heads about 'contact' and 'non-contact', has given rise to the suggestion that many of the mines laid in 1939-45 were in the purely technical sense not covered by the strict letter of the Convention at all, being of the automatic non-contact type (e.g. magnetic, acoustic, &c.).

The point, however, is of merely academic interest, and no lawyer would accept for a moment the proposition that the

Convention did not in reality cover the use of non-contact as well as contact mines. Both types are automatic, and it is not only more than arguable that there is nothing to distinguish them from the legal point of view, but no belligerent has ever attempted to justify their proceedings on the grounds that such a distinction can be made.

The third clause of Article I reads:

It is forbidden to use torpedoes which do not become harmless when they have missed their mark.

The reason for the inclusion of a reference to torpedoes in a Convention dealing with mines is that a torpedo which has failed to strike the target becomes in effect an unanchored mine at the end of its run, provided, of course, that it has sufficient buoyancy to remain afloat. In point of fact, the modern torpedo seldom has this buoyancy.

Article II

Article II reads as follows:

It is forbidden to lay automatic contact mines off the coasts and ports of the enemy with the sole object of intercepting commercial navigation.

This clause, which by implication referred to both anchored and unanchored mines, was all that remained of attempts to restrict the extent to which minelaying should be permitted on the high seas.

The German delegation objected to the clause on the grounds that it contained a subjective element which was absent from the remainder of the Convention, and which would give rise to difficulties in practical application. The British delegate suggested that the case would be met by a prohibition to lay mines off commercial ports—or, alternatively, a permissive to lay them off naval ports only, but the German objection was unquestionably sound. As foreseen by them, it is extremely difficult to show that a particular group of mines has been laid for the *sole* purpose of intercepting commercial navigation. It can always be claimed by those who lay the mines that their purpose is to endanger war vessels passing through the waters in question.

The Colombian delegate moved a resolution which *inter alia* proposed an absolute embargo on the laying of mines in the open sea or in the waters of an enemy. He supported this resolution with an impassioned and eloquent appeal to the Great Powers to set an example and to prove their sincerity in the cause of humanity. In his submission, if the use of mines could not be suppressed absolutely, such use should be limited to the needs of coastal defence.

This appeal was well received, and was supported by Great Britain and China, the latter country having suffered considerably as a result of the minelaying operations in the Russo-Japanese War. Both Germany and Austria-Hungary objected on the grounds that it would be difficult to distinguish between attack and defence, instancing the case of a blockading squadron against which it might be desired to lay mines at any distance up to twenty miles from the coast.

Sixteen states voted in favour of the Colombian amendment, and fifteen against, while six abstained from voting and seven were absent. The amendment therefore failed, as the majority in favour was not absolute, and Article II was adopted by thirty-three votes, with three abstentions and seven absentees. Both Germany and France made reservations, and there can be no doubt that this Article is the least satisfactory of the whole Convention, its uselessness as a restraint upon the mining of commercial routes being confirmed by experience in the two world wars.

On 7 August 1914 Germany communicated to neutral Powers her intention to close the trade routes to English ports by mines and proceeded to lay mines indiscriminately on those trade routes both inside and outside territorial waters. The German Government, in addition to relying on its express reservation to Article II, pointed out that the Article did not stipulate the distance from the coasts and ports of an enemy at which mines might be laid. In 1939 Germany adopted the same policy of offensive minelaying on the trade routes.

In World War I, British mines were not laid until after the Germans had laid mines on the trade routes, an illegal proceeding which was held to justify the British reprisals. In 1939, however, British offensive minefields laid in specified

areas off the German coast were notified to neutral governments and shipping warned by radio at a very early stage of the war, it being held that these minefields had as their primary object the destruction of German surface war vessels and U-boats, and were therefore perfectly legitimate under Article II.

The German incursions into Norway and the Low Countries, followed by the fall of France, with the concomitant declaration of larger and larger 'war zones' or 'danger areas', led, as described in earlier chapters, to an extension of the British offensive minelaying operations. It was inevitable that these operations should affect the trade routes to enemy-controlled ports, but the British invariably made every effort to safeguard neutral shipping, whereas the Germans did not. On the other side of the picture, the German minefields were for the most part specifically aimed at commercial shipping, whereas the British minefields were not.

Article III

Article III, the longest, reads as follows:

When anchored automatic contact mines are employed every possible precaution must be taken for the security of peaceful navigation.

The belligerents undertake to provide, as far as possible, for these mines becoming harmless after a limited time has elapsed, and where the mines cease to be under observation, to notify the danger zones as soon as military exigencies permit, by a notice to mariners, which must also be communicated to the governments through the diplomatic channel.

This article was unanimously adopted, Turkey alone reserving the right to take any steps she thought fit to preserve the neutrality of the Dardanelles and the Bosphorous, or to defend those straits should she herself be at war.

The intention of the proviso that mines should become harmless after the lapse of a limited time is not clear. It has certainly never been taken to mean that they should be *designed* to become ineffective after a pre-determined time. Rather have the efforts of designers been devoted to the production of mines which will withstand the ravages of Nature for the maximum possible period.

The curious distinction between 'peaceful navigation' in this article, and 'commercial navigation' in Article II is also worth noting. It is presumed that the latter expression is intended to refer to neutral merchant ships, whereas 'peaceful navigation' includes neutral war vessels in addition. If this be so, a purist might be led to the conclusion that, taking both articles as a whole, it is permissible to lay mines in enemy waters for the sole purpose of intercepting neutral war vessels.

The phrase 'where the mines cease to be under observation' has generally been interpreted by Great Britain to mean that patrols must be stationed to keep shipping clear of minefields laid for defensive purposes until it is deemed that sufficient time has elapsed for the warning notices to have been received by all concerned. Mines laid in enemy waters presumably cease to be under observation as soon as the operation is completed and the minelayers have departed.

The general spirit of the provisions for the security of peaceful navigation and the promulgation of warning notices has always been observed by Great Britain, and in 1939-45 was amplified by radio broadcasts. The policy of informing the world of our intention to lay mines, when the enemy did not, was severely criticized on one or two occasions. The critics failed to realize the operational and political advantages to be derived from this adherence to our international obligations.

In neither of the two world wars did Great Britain declare the existence of deep minefields laid for the purpose of trapping submerged U-boats. In all such cases steps were taken to ensure that after laying no mines remained at a depth dangerous to surface vessels. This procedure was held, with every justification, to be in keeping with both the spirit and with the letter of the Convention. The sole purpose of these minefields was to assist in the *protection* of shipping, in that the only craft endangered by them constituted one of the principal menaces to that shipping.

Similarly, in circumstances where traffic was under complete control, the declaration of mined areas was withheld if by so doing their effectiveness against the enemy was enhanced without endangering commercial shipping. The criterion, as always, was the safety of friendly and neutral traffic.

As World War II progressed and more and more of the European coastlines came under enemy control, the areas declared to be dangerous due to British mines were gradually extended and in the later stages merged with the general combat areas, which ships were warned to avoid. Throughout the war, however, and to our great operational disadvantage, we scrupulously left unmined a wide channel leading through the Skagerrak to Swedish territorial waters, and at no time were Swedish ships denied access to the Atlantic.

Furthermore, there was no recorded case of a neutral vessel being sunk or damaged due to a failure on our part to promulgate the necessary mine warnings. All such mishaps were attributable either to a deliberate disregard of the warnings or to an error of navigation.

The weakest point of this article is the 'military exigencies' clause, which, if handled with plausibility, may completely defeat the object.

Article IV

Article IV read as follows:

Neutral Powers which lay automatic contact mines off their coasts must observe the same rules and take the same precautions as are imposed on belligerents.

The Neutral Power must give notice to mariners in advance of the places where automatic contact mines will be laid. This notice must be communicated at once to the Governments through the diplomatic channel.

This is simply Article III as applied to neutrals, and with the obvious omission of the military exigencies clause.

Article V

Article V dealt with the problem of post-war mine clearance:

At the close of the war, the Contracting Powers undertake to do their utmost to remove the mines which they have laid, each Power removing its own mines.

As regards anchored automatic contact mines laid by one of the belligerents off the coast of the other, their position must be notified to the other party by the Power which laid them, and each Power must proceed with the least possible delay to remove the mines in its own waters.

This article was unanimously adopted, and formed the basis of the post-war mine clearance operations after both world wars. The suggestion that the victors should exchange full information with the vanquished has not, of course, been followed, but it must be remembered that the Convention did not foresee the advent of the *non-contact* mine, with all its secrets. After both wars, the defeated enemy has been required by the Instrument of Surrender to declare the position and nature of all her minefields, and the method by which they can be swept. The apportioning of the work of clearance and the distribution of ex-enemy minesweepers according to the needs and resources of all concerned (including neutrals) has then been decided by an International Mine Clearance Board.

Article VI

Article VI attempted the impossible:

The Contracting Powers which do not at present own perfected mines of the description contemplated in the present Convention, and which, consequently, could not at present carry out the rules laid down in Articles I and III, undertake to convert the material of their mines as soon as possible, so as to bring it into conformity with the foregoing requirements.

Incredible though it may seem, this article was unanimously adopted, a proposed amendment by the British delegate to set a time limit for the conversion being defeated. To the credit of Turkey, it must be recorded that she made a reservation to the effect that no undertaking could be given to transform her mining material into any system *not generally known*.

Article VII

The provisions of the present Convention are only applicable between the Contracting Powers, and only if all the belligerents are parties to the Convention.

The fact that neither Russia nor China were signatories does not invalidate the Convention. Multilateral conventions, to which the majority, though not all, states, are parties, have great authority because they are the formal expression of what the parties have agreed the law is or ought to be.

H.M. Government in both world wars applied the Convention. The German Government in 1914 declared that it held itself as voluntarily bound by the Convention (subject to the reservation of Article II made by Germany at the time). In 1939 Admiral Raeder said that the use of mines would, as hitherto, continue to be kept strictly within the framework of this Convention.

Articles VIII, IX, X, XI, XII, and XIII

These articles dealt with the ratification of the Convention, the accession of non-signatory Powers, the date on which it should take effect, the period for which it should remain in force, the reopening of the question of the employment of automatic contact mines, and the keeping of a register at The Hague. The main point of interest is that the Convention was due for reconsideration in 1914, but the First World War intervened, and so it remains the sole instrument for the conduct of mine warfare.

Summary

With all the best will in the world, the Convention cannot be regarded as anything but an unsatisfactory document, and it was so described by jurists of international repute at the time of its adoption.

The genuine desire to safeguard neutral interests was largely defeated by the 'military exigencies' clause in connexion with the issue of warning notices to mariners, and many of the provisions were adopted by very narrow relative majorities, and not by an absolute majority of the votes of *all* the delegates.

Anyone who has been charged with the framing of a set of rules for the conduct of human affairs will agree that the permissive type of order is more satisfactory than the prohibitive. It seems fair to suggest that in general the British mentality tends to the acceptance of the former type, based on sound principles, whereas the Continental peoples prefer the latter. This is to some extent borne out by the British attitude at The Hague, when a reservation to the final convention was entered in the following terms;

In placing their signatures to this Convention, the British Plenipotentiaries declare that the mere fact that the said Convention does not prohibit a particular act or proceeding must not be held to debar His Britannic Majesty's Government from contesting its legitimacy.

Sir Ernest Satow, the leader of the British delegation, then exposed the weaknesses of the Convention and summarized the views held by many of the delegates in a declaration of such force that it is worth reproducing in full:

Having voted for the Mines Convention which the Conference has just accepted, the British Delegation desires to declare that it cannot regard this arrangement as furnishing a final solution of the question, but only as marking a stage in international legislation on the subject. It does not consider that adequate account has been taken in the Convention of the right of Neutrals to protection, nor of humanitarian sentiments which cannot be neglected; it has done all that is possible to bring the Conference to share its views, but its efforts in this direction have remained without result.

The high seas, Gentlemen, are a great international highway. If in the present state of international law and custom belligerents are permitted to fight their battles there, it is none the less incumbent on them to do nothing which might, long after their departure from a particular place, render this highway dangerous to neutrals who have an equal right to use it. We declare without hesitation that the right of the neutral to security of navigation of the high seas ought to take precedence of the transitory right of the belligerent to employ these seas as the scene of the operations of war.

This Convention, however, as it has been adopted, imposes on the belligerent no restriction as to the placing of anchored mines, which consequently may be laid wherever the belligerent chooses, in his own waters for self-defence, in the waters of the enemy as a means of attack, or lastly on the high seas, so that neutral navigation will inevitably run great risks in time of naval war, and may be exposed to many a disaster. We have already on several occasions insisted on the danger of a situation of this kind. We have endeavoured to show what would be the effect produced by the loss of a great liner belonging to a Neutral Power. We have not failed to produce every argument in favour of limiting the field of action of these mines, while we called special attention to the advantages which the civilized world would gain from this restriction, as it

would diminish to a certain extent the causes of armed conflict. It appeared to us that by accepting the proposal made by us at the beginning of the discussion dangers would have been obviated which in every maritime war of the future will threaten to disturb friendly relations between neutrals and belligerents. But since the Conference has not shared our views, it remains for us to declare in the most formal manner that these dangers exist and that the certainty that they will make themselves felt in the future is due to the incomplete character of the present Convention. As, in our opinion, this constitutes only a partial and insufficient solution of the problem, it cannot, as has already been pointed out, be regarded as a complete exposition of international law on the subject. Therefore the legitimacy of a given act cannot be presumed for the mere reason that the Convention has not forbidden it. That is a principle which we desired to affirm, and which could never be ignored by any state, whatever its power.

It is not the purpose of this book to engage in the drafting of international conventions, but if and when this task is undertaken by those best qualified to do so, it is suggested that the greater part of the existing Convention might well be replaced by a simple sentence to the effect that:

The Contracting Powers undertake to give adequate warning of any danger to neutral shipping which may result from the laying of mines.

Such an undertaking would place upon a belligerent laying mines of *any* type the onus of deciding whether any danger to neutrals might ensue, and would leave to him the methods to be adopted for the promulgation of such warnings as might be considered necessary.

The acid test of these methods would be their adequacy.

CHAPTER X

RETROSPECT AND PROSPECT

IN dealing with the past, an attempt has been made to present an objective report. The purpose of this, the final chapter, is to summarize the lessons learned and to seek the shape of things to come, and as it is by definition impracticable to report the future, some intrusion of personal opinion will be unavoidable.

In accordance with practice, the author, when qualifying as a torpedo officer in 1923, was required to deliver a lecture to his fellow students and to those members of the staff of H.M.S. *Vernon* who cared to attend. The subject allotted to him was 'The Place of Mines in Future Naval Warfare', and after the burning of much midnight oil a discourse was evolved of which three-quarters turned out to be about naval warfare and only one-quarter about mines. Later experience, both in the framing of policy and in the execution of plans, has shown this to have been a just balance. As we have seen, the mine by its very nature tends in peacetime to fall within the province of the technician rather than the planner, and this tendency must be resisted if the weapon is to be developed on rational lines and used with effect when the time comes.

Sea-power alone does not win wars, but in the case of the British Empire it is essential to their winning, and it would be reasonable to add that minelaying is simply one of the methods by which sea-air power can be exercised with effect. A study of war is thus an essential preliminary to a study of minelaying.

In tracing the development of underwater attack, two salient points emerge. The first is the circular nature of that development, admittedly discernible in all types of 'progress', but particularly so in this case. Except for the difference in mechanical contrivance, there is little to distinguish the technique proposed by Bushnell and Fulton for fixing a 'magazine' to the hull of a ship and that followed in World War II for securing a limpet mine in the same position. So exact is the parallel, in fact, that the account of such an attack

against a Japanese cruiser in July 1945 is worth recording here. The *Takao*, of 9,850 tons, was lying in the Johore Straits (Singapore) when the midget submarine XE3 set out under the command of Lieutenant Ian Fraser, D.S.C., R.N.R. After a hazardous passage of eleven hours, during which she narrowly escaped detection and on one occasion deliberately entered mined waters to avoid an enemy hydrophone listening station, XE3 slipped past the trawler guarding the gate in the boom at the entrance to the Johore Straits. After passing a boat filled with Japanese sailors at a range of 25 yards, she scraped along the bottom in depths of water varying from 15 to 22 feet until she finally hit the side of the cruiser with what her Commanding Officer described as a resounding crash. The *Takao* was found to be nearly touching the ground both fore and aft, but after about forty minutes of violent manœuvring Lieutenant Fraser succeeded in extricating his craft from a hole into which she had fallen and forcing her under the centre of the enemy cruiser.

In this position, the hatch of the XE3 would not open fully, but her diver, Leading Seaman J. J. Magennis, squeezed himself out and proceeded to fix his mines. Owing to the foul state of the hull, they would not stick, and he had to scrape several years' growth of barnacles and seaweed away before he could get them to do so. This took him forty-five minutes, handicapped throughout by a constant leak from his breathing apparatus, which caused a stream of tell-tale bubbles to rise to the surface. Exhausted after his return to the submarine, Magennis none the less volunteered to go out again and release one of the mine carriers which had jammed and so could not be jettisoned. It was essential to get rid of this carrier, which would have upset the trim of the submarine, and Magennis managed to do so after seven minutes' exhausting work with a large spanner. The XE3 then withdrew, and after breaking surface once when just over a mile from her victim she reached the open sea, to be taken in tow by a waiting British submarine, the *Stygian*. This remarkable and successful adventure had taken sixteen hours, and both Lieutenant Fraser and Leading Seaman Magennis were awarded the Victoria Cross.

It will be remembered that in an earlier chapter the limpet mine and its predecessors were described as being torpedoes rather than mines. The example of their use quoted above should not necessarily be taken as suggesting that the wheel of operational thought has also turned full cycle, because it is obvious that the introduction of the non-contact or influence mine, coupled with the potentialities of aircraft as minelayers, has exercised and will continue to exercise a profound effect on the conduct of mine warfare. None the less, one of the most certain ways of damaging a stationary ship still lies in fixing an explosive charge to her hull, and we should do well to bear in mind the potentialities of the modern small submersible craft in this connexion.

The second point of interest is the time-lag which frequently occurs between the inception of an idea and its practical application. Several examples have already been quoted, such as the detachable charge case, the hydrophone, and the sprocket-wheel type of sweep evader, and there are many others. There are two probable reasons for this time-lag. Many clever ideas, when originally put forward, frequently form but a small part of some much larger proposal. On investigation, the latter is found to be either unwanted or impracticable at the time, and it is discarded as a whole, carrying into oblivion the ingenious but apparently insignificant component part. Secondly, new ideas are often discarded because they cannot be made to work with the materials available or under the manufacturing processes in vogue at the time of their inception. The 'period' of these cyclic revivals is also governed to a large extent by the intervals at which major wars occur, it being common knowledge that the tempo of scientific and engineering development is always increased under the stimulus of national emergency. Whatever the reasons for this cyclic phenomenon, the benefits to be derived from an occasional inquiry into the 'ingenious but futile efforts of our ancestors' are manifest.

In the material sphere, then, the ideas of the past may often serve as an inspiration for the future, but it is suggested that when dealing with the operational employment of that material we should be careful to avoid the error of confusing

precedents with principles. Because a certain thing done in one war achieves certain results, we should, before repeating the process in another war, be quite clear as to *why* the thing was done, and *why* it did achieve those results. If this be true, and it seems on the face of it to be an irrefutable presumption, then it will be profitable to try to set out the factors which must always be considered before embarking on a minelaying project.

As in all human undertakings, ranging from the crossing of a street to the building of an aircraft-carrier, it is essential to be clear as to the object to be achieved by a particular course of action. First and foremost, then, the *purpose* of a proposed minelaying operation or series of operations must be established beyond doubt. Laying mines merely for the sake of doing so can achieve nothing, and may lead to acute embarrassment, if not disaster. Secondly, it is essential to inquire into the technical possibilities and the supply situation. It may be highly desirable, from the operational point of view, to lay mines in a particular locality, but if the water is too deep for non-contact ground mines or the tidal conditions are too severe for moored mines, no amount of drawing lines on charts will serve to change the course of Nature. It may then be necessary to inquire whether the importance of the project would justify the design and production of special material, or the setting up of special storage and supply arrangements.

Thirdly, it is well to find out whether any other interests are involved. For example interference with air-sea rescue craft or fishing vessels, or damage to telegraph cables, may be unacceptable. Similarly, it must be clearly established that neither the freedom of movement of Allied forces and convoys nor the conduct of future operations will be prejudiced. In waters under the control of those who lay the mines, this question need not present any great difficulty, as both the position and the shape of the minefields can be adjusted to meet any foreseen requirements. If any adjustment is later found to be necessary, it can generally be effected by sweeping and relaying individual minefields.

In enemy waters, however, it may be a matter of the utmost concern, because such minefields, once laid, become the

property of the enemy, and he can do what he likes with them. That is to say, he can try to sweep them up or to sweep a channel through them, or he can divert his traffic round them, or he can leave them to form part of his own defences. From the point of view of those who lay them, therefore, the effective *life* of such minefields is of just as much importance as their *position*. Psychologically, it is not easy to call upon people to risk their lives in the laying of mines whose period of lethality is deliberately restricted, but from the British point of view at least it can be said without hesitation that both the effectiveness and the scope of the offensive campaign in 1939-45 was directly attributable to the ability to impose such restrictions with accuracy.

There is the parallel problem of keeping friendly warships informed of both the position and the composition of minefields which are still effective. In World War I a high degree of secrecy was observed in this connexion, and there were several occasions on which the operations of British ships were adversely affected as a result. In World War II this policy was deliberately reversed, and the 'Q' message system used to promulgate the details of British as well as enemy minefields to all war vessels. The possible loss of security was completely offset by the freedom of movement thus conferred, but there were occasions on which enemy ships passed through areas presumed to be dangerous and so avoided being brought to action. Maddening though this may be, it must be remembered that the state of effectiveness of a live minefield is difficult to assess after a certain lapse of time; that some margin of safety had to be left round the actual mines when issuing the warning messages, and that by the laws of probability there is always some chance of a ship passing through a minefield unscathed (see Appendix I). On these occasions, moreover, it must also be remembered that the enemy ships conducted themselves with the confidence born of ignorance.

This book has dealt chiefly with the independent mine, as opposed to the controlled mine, and there can be no doubt that the great disadvantage of the former is in fact its independence. Some method of controlling all mines, whether laid for the defence of harbours, in the open sea, or off the coasts

and ports of the enemy, would be the greatest boon. It is therefore of more than passing interest that the Torpedo School Report for the year 1913 describes a proposed method of rendering independent mines safe for the passage of friendly ships. This proposal is headed 'The Acoustic Mine'.

Lastly, the necessity or otherwise to declare the limits of a dangerous area in accordance with international law must be considered. As we have seen, the only existing instrument on this subject is the Eighth Convention, made at The Hague in 1907.

The intentions and the implications of this possibly inept piece of legislation have been discussed, and it will be apparent that the declaration of 'paper' minefields and the exercise of cunning in the employment of various technical devices form part of the stock-in-trade of those who seek to bluff their opponents. A separate volume could be written on the art of bluff, but it will suffice here to draw attention to the subtle distinction between bluff and trickery. When confronted by an illusionist who saws a woman in half, or by a conjurer who smashes a gold watch to smithereens and then reconstitutes it as an omelette, the intelligent observer is consoled by the fact that the woman cannot really be sawn in half or the watch really destroyed. The observer, in short, is simply called upon to admire the skill of the performer. The same intelligent observer, however, may pay out quite a lot of money for the privilege of proving to a plausible citizen in a third-class railway compartment that he *knows* which of three cards is the queen of spades. He is being bluffed, as opposed to being tricked, and it is rather curious that this particular performance is called 'the three-card *trick*'.

Bluff, it would therefore seem, consists either in making your opponent convince himself that something has happened when in fact it has not, or in making him convince himself that something has not happened when in fact it has. Had the British used the Oyster pressure mine before the Germans did, it is of interest to speculate whether the enemy would have refrained from using his version on the grounds that the British would never have done so unless they had developed a satisfactory countermeasure. Some such suggestion was in fact made at the time.

To take the matter of bluff one stage further, it is of importance that any *ruse de guerre* should be devised with the utmost attention to detail, the object being to produce something so nearly resembling the genuine article that the difference can not be discerned by normal methods. Finally, the perpetrator of any form of bluff must beware that he does not become the victim of his own ingenuity.

So much, then, for the general factors to be considered when planning a series of minelaying operations. It may now be worth while to particularize a little, and to consider first the question of anti-submarine barrages. We have seen that in two successive wars much time and effort has been expended on this form of protection, and that in both cases the soundness of such a policy has been, to say the least of it, a matter of opinion. From the purely physical point of view, it seems fair to say that only in exceptional circumstances can an effective mine barrage be established over more than a comparatively short front or to cover more than a comparatively shallow depth of water. It would be misleading to quote quantitative examples, but if these special circumstances are not present, then the purely practical considerations all operate to prevent a barrage system, which may be quite sound in theory, from being established *and maintained*. Furthermore, we have the paradox that although a system of minefields can seldom if ever be a complete substitute for the activities of mobile forces, yet the cry for minefields goes up whenever there is a shortage of such forces. The time required to produce the latter in adequate numbers may well be about the same as that required to lay a barrage of reasonable density, and as time, particularly in the early stages, becomes more important with each successive war, the argument for having sufficient mobile forces at the outset seems to be overwhelming.

There are three main types of locality in which submarines can be menaced by minefields: either on their own doorstep, or while in their area of operations, or while on passage between the two. Under modern conditions, the latter locality offers the least chance of success, and with the advent of aircraft as minelayers and the technical development of the influence mine, the former should offer the best. That is why, in spite

of the establishment of enemy submarine bases in Norway and in the Biscay ports in World War II, the number of U-boats sunk by mines in both wars was more or less the same. As suggested in an earlier chapter, the reason that the depth-charge did so much better in the second war than in the first was that its *tactical* effectiveness rested on the methods of detection available. The minefield remained a strategical weapon depending largely on geographical considerations and on the extent to which U-boats came to it.

A further point to be noted is that unorthodox systems of minelaying are only of value in the circumstances for which they are designed. This may appear to be an embellishment of the obvious, but there is a recurring tendency for the value of such things as drifting mines and connected mines to be grossly overrated. Drifting mines, for example, can be used with effect in a river, and a special organization was in fact set up in the early days of World War II to drift a variety of small mines down the Rhine, the object being to endanger enemy bridges, pontoons, barges, and river craft in general. Some success was achieved, but this was the use of special material designed for a special purpose. Attempts were made to lay these mines, connected together, ahead of enemy ships off the Dutch and French coasts. Under the most perfect conditions, however, such efforts are more or less foredoomed to failure, because no drifting body remains in the same position for more than a few minutes, and connected drifting bodies always tend to bunch together. Apart from these practical difficulties, drifting mines laid in the open sea are more often than not an embarrassment rather than a help. Moored mines connected in pairs are complicated to lay, their natural life is short, and the theory that they have double the chance of success is mathematically unsound.

Incidentally, the legend has grown up that all drifting mines are dangerous to shipping, but this is by no means the case. When moored, mines are normally kept dangerous due to the tension in the mooring rope, and if they break adrift the tension is relaxed and a strong spring takes charge, so opening a switch in the circuit between the firing battery and the detonator. If a mine breaks adrift with a length of mooring

trailing from it, that mooring may get caught up on rocks, pier structures, and so forth; the mine in effect becomes moored once more and so liable to detonate if one of the horns is struck. This, however, does not mean that it was dangerous while adrift, and similarly a mine which explodes on being penetrated by fast-moving particles of metal when subjected to rifle or gunfire is not necessarily dangerous to shipping. Finally, it is extremely difficult to ram a mine or any small object floating freely on the surface of the sea. The chances of a ship being sunk or damaged by a mine which has broken adrift from its moorings are in fact remote, but none the less the prudent seaman will give them a clear berth.

In what may be termed the technical-operational sphere, Great Britain has passed through three phases. First, a period of indifference to the significance of mine warfare, based on a combination of arrogance and apprehension; secondly, a period of awakening, but one in which the scope of the operations was largely dictated by the type of material which could be made available; and lastly a period in which the material produced was specifically designed to meet the operational requirements and the technical possibilities were continually brought by the designer to the notice of the planner. A statement of the direct casualties inflicted on the enemy in this last phase has already been given, but the importance of the *indirect* effects cannot be emphasized too strongly.

The most notable of these indirect effects was the holding up of essential ships and cargoes and the interruption of vital supplies. For instance, the laying of eleven mines by Mosquito aircraft in the Kiel Canal in April 1944 was estimated to have resulted in a virtual loss to the enemy of over 1,000,000 metric tons of cargo, although not one ship was sunk. It is, in fact, not always realized that every ship held up, even for a day, represented a loss of cargo, because on the conclusion of the war the enemy was left with an adverse balance of ship-days which he could never liquidate. Similarly, the iron-ore traffic from Scandinavia to the Ruhr and from Bilbao to Bayonne was frequently suspended, every hour of delay being reflected in a dislocation of the basic industries which relied on a steady

flow of supplies. Again, the loss of quite small parcels of special raw materials carried in blockade-runners or of such things as spare lenses for U-boat periscopes might and did have an effect out of all proportion to their actual bulk.

Other important effects were the diversion of traffic and U-boats into areas in which they were more vulnerable to attack by other means, interference with the movement of troops and equipment, and the overloading of other methods of transport due to the necessity to transfer freight from mined sea-routes.

The German Admiral Doenitz, when questioned after the war as to the effect of the British minelaying campaign on the conduct of U-boat operations, replied that U-boat training was not interrupted. This was a good example of the old police-court technique of answering a different question to the one asked, for he then went on to say that this immunity was achieved by moving all the training areas to the Eastern Baltic, and that this proved effective until the Russian advance to the west. If words mean anything at all, it is suggested that training was in fact affected, in that the enemy was forced to adopt a course of action which he would not have followed by his own choice. Moreover, the time required for individual U-boats to reach their operational areas was increased, both by the extra distance to be covered and by the necessity to sweep a passage for them. Even so, more than half the mining casualties to U-boats were inflicted *in enemy waters*, a sinister commentary on the effectiveness of the British mines and the inadequacy of the German sweeping organization.

Further indirect effects were the raising of marine insurance rates, the refusal of neutral crews to sail, and the eventual withdrawal of neutral tonnage from trade with Germany. Finally, it will be appreciated that the sinking of specialized craft, such as train-ferries, dredgers, ice-breakers, tugs, and salvage vessels, had an effect which was quite disproportionate to the intrinsic value of the ships themselves, and that the repair of damaged merchantmen had a disturbing and cumulative influence on the activities of the German shipyards.

All the above factors, coupled with the actual losses inflicted and the steady increase both in the quality and in the weight

of the attack had the ultimate effect of swamping the enemy defences, and by their own confession the Germans were in the concluding months of the war unable to cope with the situation.

If for no other purpose than to serve as a guide to the student, it therefore seems proper to seek the fundamental reasons for the results achieved by Great Britain in 1939-45.

The chief reason was co-ordination of effort at all levels and on *all* aspects of mine warfare. From the laying point of view, each project took its place as part of one large strategic concept, and there was a definite plan of campaign directed to the progressive deployment of all the available resources and to the unrelenting pursuit of the enemy. This plan involved the participation of a number of people, each one of whose activities was in its own particular sphere essential to the proper functioning of the machine as a whole.

Whether in uniform or in plain clothes, those engaged on basic scientific research, on design, on experimental and trial work, and on the supply, the inspection, and the preparation of the mines all played their part, backed by those in factory and workshop, and in daily touch with the Naval Staff at the Admiralty. This harmony of effort, moreover, was by no means confined to the Admiralty side of the organization; the high degree of inter-Service co-operation established with the Royal Air Force was a notable feature of the proceedings, and one which contributed as much as anything else to the results achieved. This happy state of affairs was epitomized in the report of the Board of Inquiry appointed to investigate the circumstances in which the *Scharnhorst*, the *Gneisenau*, and the *Prinz Eugen* made their sortie from Brest in February 1942. As we have seen, the minelaying operations were successful, and the Board confined themselves to the following statement:

We have no comment to make on the minelaying. The work appears to have been skilfully done both in planning their position and in the actual laying of them by the two Services in co-operation.

Against Germany, it was possible to organize on a flexible basis, and to superimpose short-term variations on the long-term plan. Distances were short, transport was adequate, and

expert advice and assistance was at all times available. Abroad, problems of storage and transport prevented the holding of more than a certain number of different types of mines, the requirements for which had to be forecast some way ahead, and the number of aircraft available for minelaying was in general smaller than at home.

In spite of this variation in opportunity, the results achieved in Burmese and Indo-Chinese waters and in the South-west Pacific were more than comparable with those in other areas, and the special case of the Danube operations has also been noted. In particular, the efforts of the Catalina aircraft of the Royal Australian Air Force in the South-west Pacific were remarkable, both in terms of mines expended per casualty inflicted and in the relatively small losses suffered by the minelaying aircraft. Considerable skill was shown in overcoming the difficulties of transport, storage, and preparation of the mines under tropical conditions, and in this respect a valuable contribution was also made by our American allies.

Although the concluding chapters of this book have been devoted intentionally to an account of British minelaying, the record would in fact be sadly incomplete without reference to American co-operation and co-ordination of effort. Once again their vast scientific and industrial resources came into play, and on every aspect of mine warfare the closest liaison was established and a common doctrine evolved. Whether in active concert with the British Empire in the South-east Asia Command or in the Pacific or in their own successful employment of mines in the throttling of Japanese communications, American genius was to the fore, and it is to be hoped that an account of these latter operations will be given to the world by them.

In the sphere of countermeasures against the German mines, scientific skill backed by seamanship and by the productive capacity of the country served to keep us one move ahead of the enemy. Every feasible combination of magnetic, acoustic, and pressure influence was investigated, and steps taken in advance to deal with those likely to prove of most value to the enemy. Thus when any new system or combination was introduced by him, the production of the necessary

antidote rested on establishing the characteristics of that new system and applying this key to the store of basic knowledge and experience accumulated in readiness for such an event. So comprehensive was the organization, in fact, that in some cases equipment was provided for types of mine actuation *which the enemy never used*, although he might well have done so.

It should not be assumed that the introduction of a new system by the enemy was countered forthwith. A rise in mining casualties was sometimes inevitable, but the magnitude and the duration of that rise was always reduced to a minimum by intelligent anticipation and by the speed with which any special equipment was provided and installed in ships and mine-sweepers.

Both in attack and defence, the collaboration between the scientist, the engineer and the naval 'user' was an important feature, and it will have been noticed that in both teams the scientist and the engineer has been given pride of place. It is by now common knowledge that the successful prosecution of a war is founded on basic scientific research, and this is nowhere more true than in the case of mine warfare. This was not universally appreciated before 1939, and it has even been suggested that the real error made by the Germans when they laid their mines in penny numbers was that this action brought the British scientist into the forefront of the battle.¹

From the distinguished scientist in his laboratory, however, to the girl inserting synthetic jewels in a piece of clock-mechanism, all concerned will agree that their efforts would have been unavailing without those of the officers and men in the minelayers, the aircraft, and the minesweepers. It could have been no picnic to take a fast minelayer, a destroyer, a submarine, a motor torpedo boat, motor gunboat, or motor launch, loaded with masses of high explosive, so close to an enemy coast that the efficiency of the local black-out could be judged; while the skill and determination of the aircrews of the minelaying aircraft in the performance of an unaccustomed role was the admiration of all. Of those whose business it was

¹ Sir Charles Goodeve, in a lecture to the Royal Society of Arts, 5 December 1945.

to involve others in these hazardous operations, it can be said without hesitation that many a grey hair was restored by the simple words, 'All back safely' spoken over the telephone in a weary dawn.

As regards minesweeping, it needs but little imagination to appreciate the courage and endurance of those engaged in this vitally important service. It was perhaps a poor consolation for them to see the results of their efforts from time to time, but it was at least *some* consolation, whereas the minelayers and the minelaying aircraft had no such reward. In both cases, the work was pushed forward with only the occasional stimulus of engaging the enemy face to face.

Turning to the other side of the picture, it seems incredible that the Germans failed to make better use of their resources. The chief reason for this failure, at any rate on the minelaying side, seems to have been jealousy and lack of co-ordination. From an interrogation of German mining experts after the war, it transpired that the earlier magnetic mines had been laid by submarines, a very sound plan. In spite of the agonized protests of the German Naval Staff, however, the Luftwaffe insisted on joining in, and, sooner rather than later, succeeded in dropping a mine where it could be recovered for examination. Upset by the unforeseen ease with which the magnetic mine had been countered, the Germans thereupon rushed into production with their acoustic mine, once more using it in dribblets because they thought the war would be over before sufficient stocks for a large-scale attack could be accumulated. Meanwhile, the Luftwaffe, annoyed at the suggestion that they were responsible for compromising the mines by dropping them on land,¹ proceeded on their own to develop a mine without a parachute. The object was to produce a mine which could be dropped with the accuracy of a bomb, but whose internal mechanism would stand up to the shock on entering the water, or, to use their own expression, a 'bomb-mine'. In spite of the formidable nature of the problem, they solved it, but they concentrated solely on the ballistic properties of

¹ British minelaying operations were always conducted on the assumption that some mines would sooner or later be recovered by the enemy, either by being raised from the sea-bed or due to aircraft being shot down with mines on board or to inaccuracy in narrow waters.

their new weapon, and incorporated in it the same actuating mechanism as the original magnetic mine. The latter was by that time more than obsolete, and the obvious but caustic comments of the German Naval Staff did little to improve the relations between the two services.

This example is typical of the whole organization. Even on the naval side, although the operations of minelaying submarines and E-boats were conducted with competence, and the material itself was excellent, there seems to have been no concerted plan of campaign. In short, the Germans appear to have made the not uncommon error of regarding technical beauty as an adequate substitute for planning.

The German minesweeping organization, in addition to the problems set by the designers of the British mines, also seems to have lacked that skill in the operational *management* of their resources which was such a marked feature of the British minesweeping organization. It may be remarked in parenthesis that it is no reflection on the efficiency of the American minelaying campaign in the East to point out that the Japanese suffered even more acutely from lack of co-ordination, a fact which the Americans were indeed quick to exploit.

On all counts, therefore, team-work was the underlying reason for the success of the Allied minelaying campaign, and lack of it was the cause of the Axis failure.

What of the future? The first and obvious point which comes to mind is that of atomic energy, and in consonance with the principles suggested at the beginning of this chapter, it would be best to consider at the outset the question of warfare as a whole.

If the nations can agree to abolish war altogether, as opposed to abolishing atomic bombs, or gas, or bayonets, or any other particular weapon, then there is no more to be said, and all books about war become museum pieces. If they do not agree to this course, we are informed that the next best alternative is the setting up of an armed police force under international control, and we therefore ask ourselves whether the armament of this force will consist of atomic bombs and nothing else? In a series of talks on atomic energy sponsored by the British

Broadcasting Corporation in March 1947, Captain Cyril Falls, the Chichele Professor of the History of War at Oxford University, made it clear that it would be madness for any power to rely *solely* on the atomic bomb, as they would thereby remain vulnerable to attack by forces armed with 'orthodox' weapons. By inference, this palpable truth applies with equal force to an international body charged with the prevention of aggression. We therefore pass on to the question of whether ships will be required either for the prosecution of a war or for the imposition of sanctions by an international force. If in the future the transport *and maintenance* of armed forces and their equipment, to say nothing of the carriage of food and raw material for the sustenance and use of those who provide that equipment, can be effected more easily by air than by sea, then once again there is nothing more to be said.

Competent observers, however, do not believe that the merchant ship or the transport will become obsolete in the foreseeable future. If this be true, then navies will also survive in a form dictated by the methods available for the application of the principles of war. The author, as a professional naval officer, hastens to quote in his unbiased support the words of Mr. J. L. Sullivan, the United States Under-Secretary for the Navy, speaking on American Navy Day in 1946:

The progress of science and the development of new weapons increases rather than diminishes the basic uses of sea-power, because its principles of mobility, flexibility, and ubiquity remain unchanged.

To pass on to the material question of whether the advent of atomic energy will increase the effectiveness of mines, a moment's reflection will show that the ability to produce a monster explosion is incompatible with mining requirements. Leaving aside the fact that atomic bombs are large, heavy, and very expensive, the initiation of an explosion of similar magnitude by the passage of a ship would be a wasteful proceeding unless it involved the destruction of a great many other ships. In other words, it would be necessary to be certain of a concentration of enemy shipping within the destructive radius of the mine at the moment of its detonation, and

correspondingly the complete absence of friendly ships. We can therefore rule out the use of mines each comparable in effect to an atomic bomb detonated under water. If, on the other hand, an explosion of reasonable proportions could be produced by the use of a really small quantity of explosive material, then either the mines could be small and a greater number carried, or the space available for the inclusion of clever methods of actuation would be increased. Alternatively, a means of *directing* the effect of a very heavy explosion would enable influence mines of high sensitivity to be laid in much deeper water than at present. The chances of adapting atomic energy to either of these purposes are obviously rather more remote than the chances of adapting it to the propulsion of motor cars, and in the broadcast talks referred to above we were told that these were very remote.

There is, however, a possibility of some increase in the depths of water in which it will be worthwhile to lay influence mines containing explosive materials of conventional type.

With regard to methods of actuation, we have seen that three of the characteristics possessed by most ships have so far been exploited either singly or in combination. Had the destructive potentialities of the ground mine been appreciated earlier, these characteristics would no doubt have been exploited earlier. It requires the minimum of technical knowledge to realize that there are various other methods by which the passage of a ship can be detected, and which might therefore be used for the actuation of an influence mine. It would be unwise to refer to this subject in any detail, but it may be said to have been fortunate that the last war did not begin where it left off.

It is, however, common knowledge that, even by the end of the war, design was tending more and more to the production of mines requiring the presence of true 'ship phenomena' to detonate them, and this type of mine, however actuated, is likely to provide the greatest headache from the counter-measures point of view. It would, however, be well to disabuse our minds of the idea that a *completely* unsweepable mine can be produced. A more correct view is that mines have been and may again be used which are difficult to cope with by

methods coming under the heading of normal operations of war.

To sum up the technical aspect, more and more 'difficult' mines, either capable of control by the laying side or of distinguishing between friend and enemy, would seem to be the goal.

Although the foregoing views may be generally accepted, it may still be asked whether similar results could not be achieved in some better way. This is a big question, but one which can be answered in a small number of words.

One of the problems with which a victor is faced is the *destructive* effect of modern war as waged on land. The cumulative pressure of sea-air power achieves its purpose without this devastation of the means of production and of the homes of those who live by that production. Mine warfare is one of the most effective instruments of sea-air power, and although many ships may be sunk or damaged by mines, the effect on the rehabilitation of a country is less marked, for man is a land animal and he normally lives, works, and breeds on the land. Mine warfare also achieves its results more economically than they could be achieved by other means, and analysis has not only shown that the mine was the most effective anti-shiping weapon used by aircraft, but that the losses of aircraft per casualty inflicted on the enemy were lower than for other forms of attack.

Admittedly, some degree of post-war dislocation is caused by the necessity to clear the seas of mines, but experience has shown that by careful preparation the essential sea routes and important fishing areas can be opened up with the minimum of delay on the conclusion of a war.

From the taxpayers' point of view, the inescapable conclusion is that for so long as wars continue to be fought, and for so long as ships continue to be used for the purpose of enabling them to be fought, the mine, if properly handled, will make an effective, economic, and by modern standards a humane contribution to victory.

As a corollary, money spent on scientific research and on the development of resources for the conduct of mine warfare is money well spent, it being noted that mine warfare is equally compounded of minelaying and minesweeping.

From the planners' point of view, knowledge of the capabilities and of the limitations of those resources, and co-ordination of effort, are the signposts which point to success, but it must never be forgotten that it takes a minimum of two people to engage in armed conflict, and that one of them must by definition be on the opposing side.

Knowledge of enemy psychology is therefore probably to be found written on the most important signpost of all.

In bringing this book to an end, I am conscious of many things left out, and of many things which might well have been left out.

The omission of the names of those connected with the art and practice of mine warfare in modern times has however been deliberate. Any attempt at their inclusion would not only have led to invidious distinctions, but would have been inconsistent with the team idea which I believe to have been the foundation of such success as may have attended their efforts.

To those who served in the minelayers and the minelaying aircraft of the Royal, Dominion, and Allied Navies and Air Forces, to those working under the Captain, H.M.S. *Vernon*, the Superintendent of Mine Design, the Director of Armament Supply, the Chief Inspector of Naval Ordnance, to those in factory and workshop throughout the Empire, and last, but by no means least, to my colleagues in the United States Navy, I therefore offer this book in gratitude and admiration.

'They maintained a front on which their achievements, although invisible to themselves, caused the greatest embarrassment to the enemy'. *Joint Admiralty and Air Ministry communiqué.*

APPENDIX I

THE MATHEMATICAL CHANCES OF A SHIP STRIKING A MINE

IN the main body of this book, some emphasis is laid on the fact that a minefield can never present an impenetrable barrier, and that to achieve a minefield density having a high probability of success may call for the laying of a very large number of mines.

Normally, the spacing between mines is governed by the effect of the explosion of one mine on those adjacent to it. If this spacing is less than a given amount, depending on the explosive charge and the type of mine firing mechanism, then the explosion of one mine may either cause adjacent mines to fire or it may render them incapable of firing at all.

For all sea-mines, in contradistinction to land-mines, this minimum spacing is *greater* than the width of the target. From this it follows that the chance of a ship being mined in attempting to pass through a given line of mines at right angles is proportional to the width of the ship and the spacing of the mines, but it must always be *less than* 100 per cent.

The simple mathematics of the problem may be stated as follows:

$$\text{The percentage chance of getting through} = \frac{s-w}{s} \times 100$$

where s = spacing between the mines

and w = width of the target at the depth at which the mines are laid.

For example, a ship presenting a target width of 50 feet has a 67 per cent. chance of getting through a line of mines spaced 150 feet apart, the normal minimum for a charge of about 500 lb. of explosive. To be strictly accurate, the chance is slightly lower, because the diameter of the mines should also be allowed for, but this is not of statistical significance.

If there are n lines of mines in the minefield, then the mean percentage chance of escape is given by

$$\left(\frac{s-w}{s}\right)^n \times 100$$

To look at the matter the other way round, the number of lines of mines n necessary to provide a given chance C of mining the ship is given by

$$n = \frac{\log (1-C)}{\log \frac{(s-w)}{s}}$$

To consider again a target width of 50 feet and a minefield consisting of lines of mines in which the mines are spaced 150 feet apart, or forty to the mile, it will be found that *four* lines of mines are required to give an 80 per cent. chance that the ship will strike *one* mine. If the front to be covered by the minefield is twenty miles, then the total number of mines to achieve this probability of success is 3,200. To raise this probability to 90 per cent. would require six lines, or a further 1,600 mines, i.e. half as many mines again to increase the chances by 10 per cent. *However many lines of mines are laid*, the ship will in theory always have some chance of getting through.

If the ship does not approach the lines of mines at right angles, then the virtual spacing between the mines is reduced, and becomes $s \sin \theta$, where θ is the angle between the course of the ship and the direction of the line of mines. It is thus clear that if the course of the ship is restricted in any way—for example in a narrow channel—then the chances of her striking a mine can be raised to 100 per cent. by laying the lines of mines to run at an angle across her path. Similarly, the same result can be achieved by spacing the mines closer together than the normal minimum, and accepting the fact that the explosion of one mine may put the whole minefield out of action. This may be worth while, but very rarely is, to catch just one ship of particular importance.

It will no doubt be realized that the foregoing considerations are of a purely theoretical nature. They assume that the target ship steers a steady course *over the ground*, making no

leeway, and that in the case of a submarine a steady depth is also maintained. They also assume that the mines remain absolutely motionless. In practice, these conditions are seldom found, and so the chances of a ship being mined are in fact rather greater. It is for these reasons that a ship finding herself in a minefield is best advised to proceed at high speed and to steer a steady course, full weight being given to the strength and direction of the wind and tide at the time.

It will also be appreciated that this theoretical approach to the subject refers only to the case of moored contact mines. The theoretical problems presented by non-contact mines, whether of the ground or the moored type, and by submerged submarines in deep anti-submarine minefields are not a little complex, and anyone sufficiently interested will perhaps attempt their solution for himself. The object of this Appendix is simply to indicate one of the important factors involved in the evaluation of any proposal to lay mines.

APPENDIX II

PRINCIPAL BRITISH MINELAYERS— WORLD WAR I

NAME	TYPE	MINES LAID	REMARKS
<i>London</i>	Battleship	2,640	
<i>Naiad</i>	Cruisers	800	Sunk as blockships at Zeebrugge, 1918
<i>Apollo</i>		1,600	
<i>Thetis</i>		800	
<i>Intrepid</i>		1,439	
<i>Iphigenia</i>		640	
<i>Andromache</i>		1,425	
<i>Latona</i>	Cruisers	2,499	Sunk
<i>Ariadne</i>		708	
<i>Amphitrite</i>		5,053	
<i>Princess Margaret</i>	Converted merchant ships and liners	25,242	Destroyed by internal explosion, May 1915
<i>Princess Irene</i>		723	
<i>Angora</i>		14,729	
<i>Wahine</i>		11,378	
<i>Biarritz</i>		5,673	
<i>Paris</i>		6,236	
<i>Perdita</i>		1,332	
<i>Gazelle</i>		243	
<i>Orvieto</i>		3,131	
<i>Royalist, Blanche, Aurora, Bellona, Phaeton, Inconstant, Penelope, Galatea and Boadicea</i>	Light cruisers	4,280	
E.24	Submarines	20	Sunk
E.41		591	
E.45		640	
E.46		240	
E.51		500	
E.34		478	

NAME	TYPE	MINES LAID	REMARKS
<i>Abdiel</i>	Flotilla leaders and destroyers	6,293	
<i>Gabriel</i>		850	
<i>Tarpon</i>		1,425	
<i>Legion</i>		2,033	
<i>Telemachus</i>		1,898	
<i>Ferret</i>		1,875	
<i>Vanoc</i>		965	
<i>Vanquisher</i>		1,859	
<i>Ariel</i>		1,237	Sunk
<i>Vehement</i>		554	Sunk
<i>Venturous</i>		1,823	
<i>Sandfly</i>		1,242	
<i>Meteor</i>		1,082	
Coastal motor boats		55	
Trawlers		9,345	
Motor launches and lighters		4,826	

APPENDIX III

PRINCIPAL BRITISH MINELAYERS— WORLD WAR II

NAME	TYPE	MINES LAID	REMARKS
<i>Adventure</i>	Cruiser/ minelayer	12,401	Damaged by mines
<i>Southern Prince</i>	Converted merchant vessels	23,762	Damaged by torpedo
<i>Menestheus</i>		22,866	Damaged by bombing
<i>Port Quebec</i>		33,494	
<i>Agamemnon</i>		24,216	
<i>Port Napier</i>		6,331	Destroyed by fire
<i>Teviot Bank</i>		15,865	
<i>Bungaree</i>		6,800	Royal Australian Navy (approx.)
<i>Plover</i>	Coastal minelayers	15,327	
<i>Van der Zaan</i>		2,198	Royal Netherlands Navy
<i>Hampton</i>	Converted train-ferries	5,190	
<i>Shepperton</i>		2,742	
<i>Princess Victoria</i>	Converted Car-ferry	2,755	Sunk by mine
<i>Abdiel</i>	Fast minelayers	2,207	Sunk by mine
<i>Manxman</i>		3,111	Damaged by torpedo
<i>Welshman</i>		3,275	Sunk by torpedo
<i>Ariadne</i>		1,352	
<i>Apollo</i>		8,361	
<i>Latona</i>		Nil	Sunk by bombing
<i>Express</i>	Destroyer minelayers	1,210	Damaged by mine
<i>Esk</i>		1,110	Sunk by mine
<i>Icarus</i>		1,196	
<i>Impulsive</i>		892	
<i>Ivanhoe</i>		754	Sunk by mine
<i>Intrepid</i>		1,592	

Mines, Minelayers and Minelaying

NAME	TYPE	MINES LAID	REMARKS
<i>Porpoise</i>	Submarine minelayers	465	Lost
<i>Narwhal</i>		450	Lost
<i>Cachalot</i>		300	Lost
<i>Seal</i>		50	Lost
<i>Grampus</i>		50	Lost
<i>Rorqual</i>		1,284	
<i>Rubis</i>		684	French
Coastal Force minelayers		6,900	Four lost
Aircraft		54,194	500 missing

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INDEX

- Abdiel*, British minelayer (1916), 54, 55,
60, 79, 80, 82
British fast minelayer (1940), 113, 147,
148, 157
Acoustic mines. *See* Mines.
attachment, 58
Admiralty Torpedo Committee, 27
Adriatic minelaying plans (1918), 84
Adventure, British minelaying cruiser, 109,
123, 130, 138, 157
Agamemnon, British minelayer, 132
Aircraft, effectiveness as minelayers, 115,
160, 165, 166
minesweepers, 129
minelaying by, 145, 147, 151, 156,
157, 161
mines. *See* Mines.
Albatross, German minelayer, 45
Albemarle attacked with spar torpedo, 22
Algiers, mine depot at, 157
Alyssum sunk by mine, 61
American Civil War, 18
Amphion sunk by mine, 45
Amphitrite, British minelaying cruiser, 59,
67, 74
Amur, Russian minelayer, 34
Andaman Islands minefield, 148
Andromache, British minelaying cruiser, 46
Angora, British minelayer, 51, 60, 67, 80
Antenna mines. *See* Mines.
Anticipatory research, 192
Anti-recovery devices, 102
-non-contact Committee, 106
-sweeping devices, 20, 44, 101
-U-boat minefields, 46, 54, 60, 61, 72,
80, 82, 84, 86, 122, 130, 159
Apollo, British minelaying cruiser (1914),
46
British fast minelayer (1944), 160
Arethusa sunk by mine, 57
Argus experiments, 14
Ariadne, British minelaying cruiser (1914),
59, 60
British fast minelayer (1943), 158
Ariel, British minelaying destroyer, 59,
74, 80, 83
Ark Royal, 151
Aroostook, American minelayer, 68
Aster sunk by mine, 61
Atomic energy, application to mine
warfare, 196
Atrius, controlled mining depot ship, 118
Attack sunk by mine, 61
Audacious sunk by mine, 47
Aurora, British minelaying cruiser, 59, 79
Australia, H.M.A.S., mining of
Kerguelen, 151
Australian waters, minelaying in, 138
mine manufacture, 138
mine storage, 117
Automatic depth-taking, 28
- BAB EL MANDEB, STRAITS OF, MINEFIELD
IN, 137
Bacon, Admiral Sir Reginald, 74
Baltimore, American minelayer, 68, 80
Barrages, effectiveness, 70, 79, 135, 187
Bass Rock minefield, 122
Battle-cruisers, German, sortie from
Brest, 151, 191
Beardmore, Messrs., 50
Beatty, Admiral Sir David, 59
Belgian coast minefields, 54, 60, 83, 147
Bellona, British minelaying cruiser, 59, 60
Berlin, German minelayer, 49
Biarritz, British minelayer, 51, 54, 61, 84
Bismarck, effect of British minefields on,
134
Blanche, British minelaying cruiser, 59, 60
Blonde, British minelaying cruiser, 59, 60
Boadicea, British minelaying cruiser, 59,
79
'Bollo' mine, 41
Bomber Command, R.A.F., minelaying
by, 145, 147, 151, 156, 157, 160,
161
Booby traps, 102
Borde, British magnetic minesweeper, 127
Boulogne, explosive catamarans, 14
Bouvet sunk by mine, 51
'Breguet' mine, 39
Breslau sunk by mine, 84
Briggs Motor Bodies, Messrs., 132
British minelaying operations. *See* Opera-
tions.
'Brooks' mine, 20
Bucknell, Assistant-paymaster C., 44
Bud, minefields off, 140
Bungaree, Australian minelayer, 138
Bureau of Naval Ordnance, American,
65
Burmese waters, minefields in, 157, 162
Bushnell, David, 7, 8, 9
- Cachalot*, British minelaying submarine,
109, 151
Canandaigua, American minelayer, 68
Canonicus, American minelayer, 68

- Cape Wrath minefields, 137
 'Carbonit' mine, 37
Carmania II, British minelaying trawler, 54, 74
Casabianca, French minelayer, 53
Cerbera, French minelayer, 46
Cerberus, frigate, attack on, 9
 Chain-conveyor minelaying gear, 111
 Channel Barrage Committee, 74
Cheerful sunk by mine, 61
 Chief Inspector of Naval Ordnance, 199
 Chinese waters, minefields in, 157, 162
 'Clickers', 136, 154
 Clocks, electric, 103
 Clyde minefield, 138
 Coastal Command, R.A.F., minelaying by, 145, 151
 Force craft, minelaying by, 147, 156, 157, 160, 162
 motor boats, minelaying by, 59, 60, 83
 Colt, Colonel, and controlled mines, 16
Commandore James, destruction by ground mine, 21
 Controlled mines. *See* Mines.
 Countermines, 25, 35
 Countermining troubles, 69, 78
 Creeping mines, 4, 50
 Crimean War, 17
 'C.R.' rod, 101
 C. 29 sunk by mine, 53
Curacao trials, 107
 Cushing, Lieutenant, 22
- DALMORE DISTILLERY, USE AS MINE DEPOT, 67
 Daniels, Mr. Josephus, 71
 Danube, minelaying in, 161
 Dardanelles, minefields, 40, 51
 'Davids', 21
 Deep minefields, 75, 78, 130, 137
 Definitions, 3
 Degaussing, 127
 Delayed arming device, 136, 154
 release sinkers, 82, 102
 Denmark Strait minefields, 134
 'Deperming', 127
 Depots, mining, 67, 117
 Depression Position Finder, 25
 Depth-taking, automatic, 28
Derwent sunk by mine, 61
 De Salis, Lieutenant R. H., 65
 Detachable charge case, 91
 Detonator, electric, 27
 'Dip' of moored mines, 77, 90
 Director of Armament Supply, 117, 158, 199
 Doenitz, Admiral, 190
 Doenitz, destruction by Fulton, 14
- Dover, Straits of, minefields in, 45, 60, 122
 Drifting mines, 4, 171, 188
 danger due to, 188
 Dummy mines, 82, 130
 Dungeness, controlled minefields, 84
 Dunkirk, 20th Destroyer Flotilla at, 147
 Durban, mine storage at, 117
 Dutch coast, minelaying off, 146, 156, 157
 first use of mines (1585), 7
- E.24, BRITISH SUBMARINE MINELAYER, 52, 55, 60
 E.21, British submarine minelayer, 52
 E.34, British submarine minelayer, 54, 60
 E.45, British submarine minelayer, 54, 60
 E.46, British submarine minelayer, 54, 60, 84
 E.51, British submarine minelayer, 54, 60
 E.41, British submarine minelayer, 60
 E.6 sunk by mine, 53
 E.49 sunk by mine, 61
Eagle, frigate, attack on, 8
 Early developments, 7
 East coast of England and Scotland
 minefields, 51, 53, 60, 83, 130
 'E.C.' attachment, 75
 Echo-sounding gear, 147
 Effect of underwater explosions, 49
 Electro-contact mines, 25
 Electro-mechanical mines, 28
 'Elia' mines, 47
 Ems River, minelaying off, 145
 English Channel, minefields in, 51, 53, 60, 137
Esk, British minelaying destroyer, 113, 140, 146, 147
 Ethics of underwater attack, 13
 European waters, minelaying in, 140, 145, 146, 147, 148, 151, 157, 160
 Evaders, mine-sweep, 44
 Explosive catamarans, 14
Express, British minelaying destroyer, 113, 140, 146, 147
- FALLS, CAPTAIN CYRIL, 196
 Farragut, Admiral, 'damns the torpedoes', 20
 Fast minelayers, 113, 147, 148, 151
Ferret, British minelaying destroyer, 59, 74, 80, 81
 Firing mechanisms, contact, 36, 92, 93
 non-contact, 95, 100, 155, 159, 197
 First Minelaying Squadron, 133, 136, 137
 Fixed mooring sinkers, 28, 77, 80
 'Flashing', 127

- Floating antenna, 134
 Folkestone-Gris Nez Barrage, 61, 72
Foyle sunk by mine, 61
 France, mining policy, 38, 42
 Franco-German War, 27
 Fraser, Lieutenant Ian, 182
 Frater mine depot, 116
 Freetown, mine storage at, 117
 French coast, minelaying off, 147, 151, 156
 Fulton, Robert, 11, 12, 14, 15
 Future developments, 196
- Gabriel*, British minelayer, 80
Gaillardia sunk by mine, 67
Galatea, British minelaying cruiser, 59, 60
Gazelle, British minelayer, 53
 Germany, errors in planning, 125, 126, 136, 195
 lack of co-ordination, 194
 magnetic mine campaign, 124, 136
 mining policy and development, 27, 38, 42, 45, 102, 162
 operations in World War I, summary, 86
 results achieved, 47, 53, 56, 61, 84, 166
Ghurka sunk by mine, 61
 Glassell, Lieutenant, 21
 Glen Albyn Distillery, mine depot at, 67
Goeben damaged by mine, 84
Goito, Italian minelayer, 41
Grampus, British minelaying submarine, 109, 147
 Grangemouth, mine depot, 67
 Grapnels, 101
 Great Belt, minelaying in, 145
 Great Britain, co-ordination of effort, 191
 mining policy and development, 30, 35, 42, 45, 47, 56, 59, 80, 88, 121, 139, 154, 158, 189
 object of campaign, 139
 resources available in 1939, 119
 results achieved, 56, 61, 78, 82, 84, 86, 123, 135, 138, 152, 157, 161, 165
 Greek waters, minefields in, 147
 Greenham mine, 92
Gromoboi damaged by mine, 34
 Ground mines. *See* Mines.
 Guncotton, adoption by Great Britain, 26
- 'H' MINES. *See* Mines.
 Hague Convention, 144, 168, 186
 Haifa, mine depot at, 117, 157
Hampshire sunk by mine, 57
Hampton, British minelayer, 114, 123, 130
 Harpoon torpedo, 14
- Harris, Air Chief Marshal Sir Arthur, 154
 Harvey towing torpedo, 24
Hatsuse sunk by mine, 34
 Heligoland Bight, minelaying in, 51, 53, 55, 59, 80, 81
Hero, British minelaying trawler, 77
 'Herz' horn, 17, 26, 88, 92
 High-speed mine sweep, 84, 105
 Himmly, Professor, 17
 Holland, German incursion into, 145
 Hong Kong and Singapore, Local Defence Flotillas, 113, 138
 mine depots, 117
Housatonic, American minelayer, 68
 (1864) sunk by 'David', 21
 Hydrophones, 64, 67
 Hydrostatic depth-taking, 29, 93, 94
- Icarus*, British minelaying destroyer, 140
 Immingham mine depot, 117
Impulsive, British minelaying destroyer, 140
 Inchkeith minefield, 138
Inconstant, British minelaying cruiser, 54, 60
 Independent mines, 3, 30, 31, 33, 35, 89, 185
 Indirect effects of minelaying, 189
 Indo-Chinese waters, minelaying in, 157, 162
 Inner Leads, Norway, 140, 145
Intrepid, British minelaying cruiser, 46
 British minelaying destroyer, 140, 146
Iphigenia, British minelaying cruiser, 46, 51
 Iron ore traffic, German, 140, 189
Ironsides attacked by 'David', 21
Irresistible sunk by mine, 51
 Italian waters, minelaying in, 147
 Italy, minelaying policy and resources, 41, 86, 101
Ivanhoe, British minelaying destroyer, 140, 147
- JACOB, PROFESSOR, 17
 Jade River, minelaying off, 145
Jane's Fighting Ships, 149
 Japan, policy and resources, 32, 40, 42
Jason class minesweepers, 36, 61
 Jellicoe, Admiral Sir John, 59
 Jutland, Battle of, minefields, 56
- Kale* sunk by mine, 84
Kate Lewis, British minelaying trawler, 77
 Kattegat, minefields in, 79
 Kegs, Battle of the, 9
 Kerguelen Island, mining of, 151

- Kharm Sound, minelaying in, 146
 Kiel Canal, mining of, 146, 147, 161
 Kilindini, mine storage at, 117
King Edward VII sunk by mine, 57
 Kitchener, Lord, 57
Koenig Louise, German minelayer, 38, 44
 Koenigsberg Canal, mining of, 161
Koryo Maru, Japanese minelayer, 33
 Kyle of Loch Alsh, mine depot, 67, 132, 150

Laforey sunk by mine, 61
 La Rochelle, use of 'floating petards' off, 7
Latona, British minelaying cruiser (1914), 51, 53
 British fast minelayer (1940), 113, 148
Laurentic sunk by mine, 61
 Lee, Sergeant Ezra, 8
 Legal aspect of mine warfare, 36, 69, 140, 144, 168
 Leghorn minefield, 148
Legion, British minelaying destroyer, 59, 74, 80
 'Leon' mine, 37
Leopard, disguise of *Manxman* as, 149
 Life of mines, artificial restriction, 5, 55
Lightning sunk by mine, 53
 Lightships, establishment by Dutch (1917), 60
 'Limpet' mines, 5, 182
Linnet, British controlled minelayer, 115
 Little Belt, minelaying in, 145
London, British battleship, as minelayer, 67
 'Loop' system of controlled minefields, 58, 79, 84, 103
 Lubeck, minelaying off, 146
 Luftwaffe, failure to co-operate, 125, 126
Lynx sunk by mine, 53

 McEvoy, Captain, 19, 56
 McKaffery-Klyne minelaying clock, 110
 Madagascar operation, 152
 Magennis, Leading Seaman, J. J., 182
 Magnetic mines, 58, 76, 83, 97, 106, 124, 152
 Magnetophone, 56
Mainz, German minelaying cruiser, 45
 Makaroff, Admiral, 33
 Malta, mine depot, 117, 157
Manxman, British fast minelayer, 113, 148, 151, 152, 156, 157
Maori sunk by mine, 53
 'Maple', Operation, 160
 Mediterranean Allied air forces, minelaying in River Danube, 161
 minefields, 51, 53, 55, 61, 84, 147, 148, 156, 160

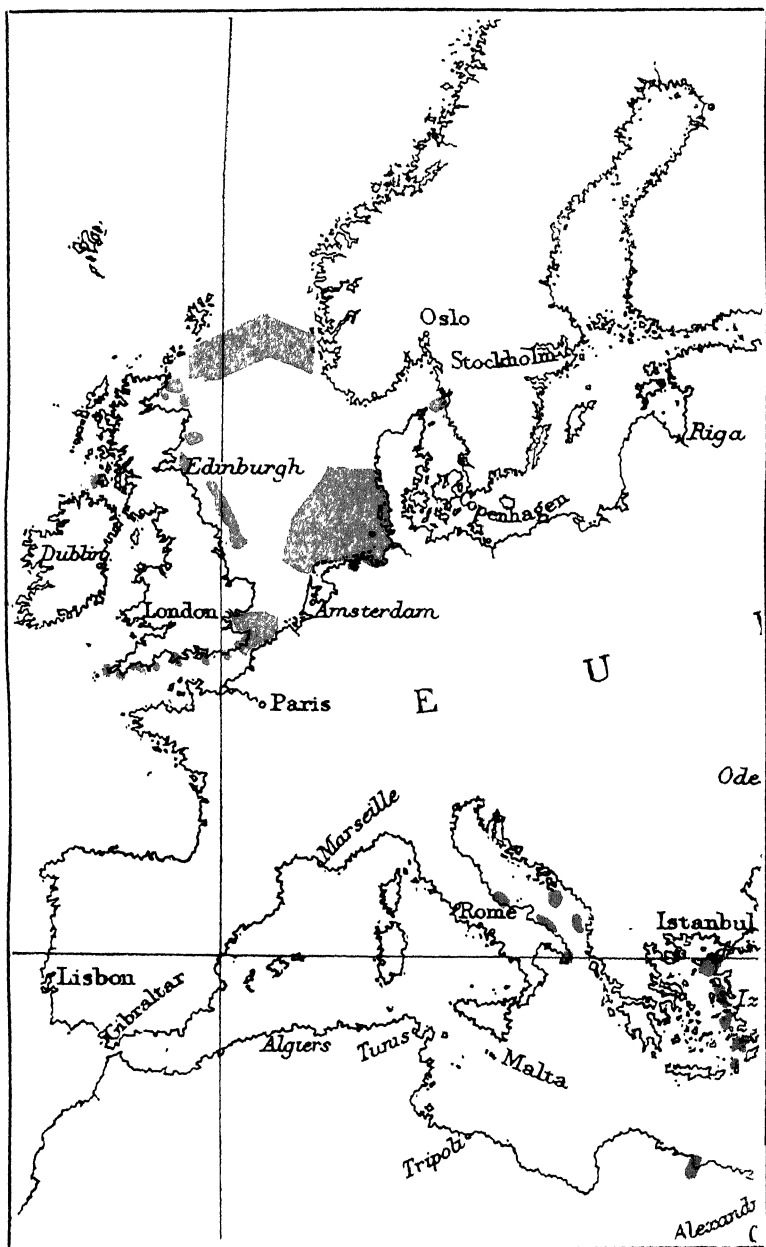
Menestheus, British minelayer, 132, 138
Merlin and *Firefly* damaged by mines, 17
Meteor, British minelaying destroyer, 59, 74, 83
 German minelayer, 53
 Middle East Command, R.A.F., minelaying by, 147, 156
Mignonette sunk by mine, 61
 Milford Haven mine depot, 117
 'Mincemeat', Operation, 148
 Mined areas. *See* Public declarations.
 nets. *See* Net mines.
 Minelayers, policy, 36, 52, 108
Minerva, Italian minelayer, 41
 Mines, acoustic, 76, 136, 155, 159, 160, 161
 antenna, 6, 65, 69, 132, 137
 'Bollo', 41
 'Breguet', 39
 'Brooks', 20
 'Carbonit', 37
 controlled, 4, 16, 17, 25, 31, 34, 47, 56, 58, 79, 84, 103, 118, 138
 creeping, 4, 50
 drifting, 4, 171, 188
 dummy, 82, 130
 electro-contact, 25
 electro-mechanical, 28
 'Elia', 47
 floating antenna, 134
 'Greenham', 92
 ground, A. Mk. I-IV, 101, 145, 162
 A. Mk. V, 161
 A. Mk. VI, 162
 A. Mk. VII, 161
 definition, 4
 magnetic, 58, 76, 83, 97, 106, 124, 152
 'Leon', 37
 'Limpet', 5, 182
 acoustic, British, 161
 early proposals, 15
 moored, H.II and H.IV, 58, 60, 66, 69, 76, 78, 89
 Mk. XIV, 91
 Mk. XV, 92
 Mk. XVI (submarine), 93
 Mk. XVII, 93
 Mk. XIX, 136, 137
 Mk. XX (British antenna), 131
 M. Mk. I (magnetic), 100
 naval spherical, 35
 snag-line, 156
 'Novoro', 41
 oscillating, 4, 25, 37, 52, 53, 81
 'Oyster', 162
 'Sauter-Harle', 39
 'Schneider', 39

- Mines, 'Scotti', 41
 Singer's, 19
 submarine, 52, 93
 Vickers, 37, 146
 Minesweeping acoustic mines, 136
 aircraft, 129
 British developments, 44, 57, 105
 early methods, 35
 German, 61, 81, 153, 195
 Jason Class minesweepers, 36
 'LL' sweep, 129
 magnetic mines, 106, 127
 pressure or 'Oyster' mines, 164
 Mine warfare, general comments, 2, 13,
 14, 36, 140, 144, 198
 Mining School, H.M. Gunwharf,
 Portsmouth, 56, 106
 Ministry of Economic Warfare, 122
Minnesota and *Memphis* damaged by
 'Davids', 21
 'Mixed bag' minefields, 139
Miyako damaged by mine, 34
 Mobile, defence of harbour by mines, 19
Moewe, German minelayer, 57
 Motor launches and coastal motor boats,
 minelaying in World War I, 59,
 61, 83, 84
 M.21, monitor, sunk by mine, 84
 'M.X.' Organization, 158
Myrmidon sunk by mine, 61
- NAB TOWER, 79
Naiad, British minelaying cruiser, 51
 Narvik, 20th Destroyer Flotilla at, 147
Narwhal, British minelaying submarine,
 109, 145, 147
 'Nautilus', Robert Fulton's, 12
 Naval aircraft, minelaying by, 146, 147,
 156, 164
 spherical mine, 35
 Net mines, 52, 54, 72
 Neutral Powers, minelaying by, 69, 87,
 176
 Nobel, development of contact mines, 15
 Non-contact mines, 4, 58, 76, 83, 95, 171,
 197
Norman, British minelaying trawler, 77
 Normandy landing, minelaying opera-
 tions, 160
 North Africa, minelaying operations, 156
 Northern Barrage, 1917-18, 61 et seq.
 North-western Approaches, minelaying
 in. 80, 137
 Norway, German occupation of, 133, 144
 Norwegian waters, minelaying in, 95,
 140, 146
 'Novoro' mine, 41
- Oberon*, trials, 27
 Object of British minelaying in 1939-45,
 139
 Observation mines, 25
 Obstructors, 101
Ocean sunk by mine, 51
 Ogilvy, Captain, minesweeping pro-
 posals, 35
 Olympic and mining of *Audacious*, 47
 Operation 'Maple', 160
 'Mincemeat', 148
 'Wilfrid', 144
 Operations, minelaying, in World War I,
 46 et seq.
 Belgian coast, 55, 83, 84
 coastal waters of British Isles, 55, 60,
 72, 83, 86
 English Channel, 60, 72
 Heligoland Bight, 55, 59, 69, 80
 Kattegat, 79
 Mediterranean, 55, 61, 84
 North Sea, 55, 69
 Northern Barrage, 69
 North-western Approaches, 80
 summary, 86
 Operations, minelaying, in World War
 II, 122
 Australian and New Zealand waters,
 138
 Baltic, 145
 Belgian coast, 147
 Burmese, Indo-Chinese and Chinese
 waters, 157, 162
 Cape Wrath, 137
 Clyde, 138
 Danube, 161
 Dover Barrage, 122
 Dutch coast, 146, 156, 157
 East Coast, 130
 English Channel, 137
 Firth of Forth, 122, 138
 French coast, 147, 151, 156, 157
 Heligoland Bight, 140, 145
 Mediterranean, 147, 148, 157, 156, 162
 Normandy landing, 160
 North-western Approaches, 137
 Norwegian waters, 140, 145, 146, 151
 Orkneys-Faroes-Iceland, 131 et seq.
 St. George's Channel, 136
 South-east Asia, 148, 151
 South-west Pacific, 157, 162
 summaries, 138, 164
 Oran, mining of, 147
 Organization, 125, 136, 154, 158
 Orkneys-Faroes-Iceland minefields, 131
 'Oropesa' sweep, 84, 105
Orvieto, British minelayer, 51, 54
 Oscillating mines, 4, 25, 37, 52, 53, 81

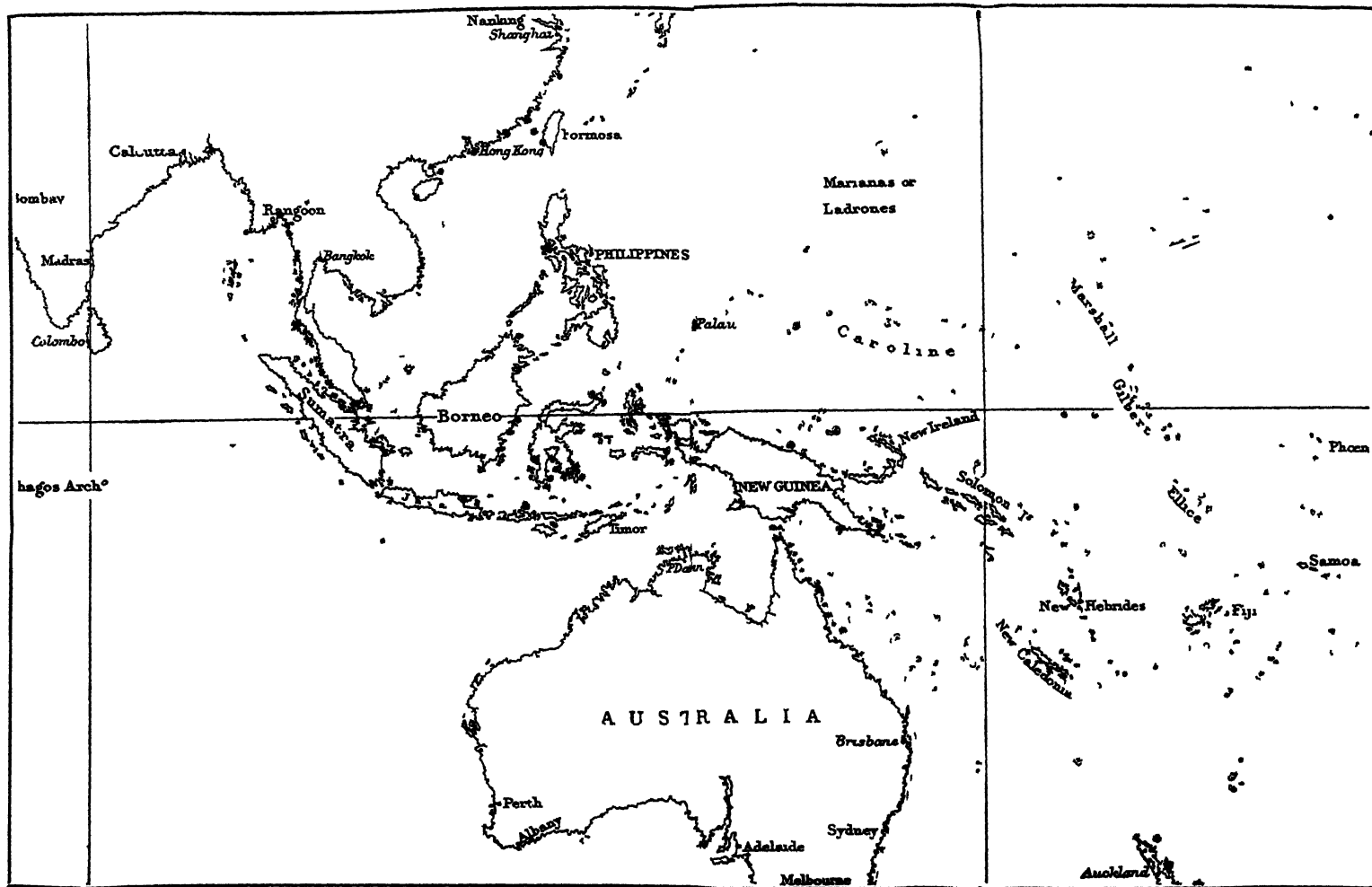
- Oslo, mining of, 145, 146
Osta, British minelaying trawler, 54, 74
Ostfriesland sunk by mine, 56
Ostrich II, British minelaying trawler, 54, 74
 Ottley, Lieutenant, automatic depth-taking, 28
 'Oyster' or pressure mines, 162
- PARAVANES, 57, 80, 106, 140
Paris, British minelayer, 51, 54, 67, 74, 83
Partenope, Italian minelayer, 41
Pataasco sunk by mine, 21
Penelope, British minelaying cruiser, 59, 79
Perdita, British minelayer, 54, 61, 84
 Period delay mechanisms, 139
Petrovavlovsk sunk by mine, 33
Phaeton, British minelaying cruiser, 59, 60
Pitfour, British minelaying trawler, 77
 Planning, importance of enemy intelligence, 3
 freedom of movement of own forces, 2
 general principles, 183
 German ineptitude, 125, 136, 195
 in readiness for World War II, 121
Plover, British minelayer, 114, 122, 123, 131, 138, 152, 160
 Plummet system of depth-taking, 29, 77, 89
Pluton, French minelayer, 46, 84
Pobieda damaged by mine, 33
 Policy, British minelaying. *See* Great Britain.
Porpoise, British minelaying submarine, 109, 146, 156, 162
 Port Arthur mine defences, 34
Port Napier, British minelayer, 132, 134
Port Quebec, British minelayer, 132, 135
 Post-war mine clearance, 177, 198
 Pound, Admiral of the Fleet Sir Dudley, 135
 Premature firing of mines, 69, 80, 134
 Preparation of mines, 117
 Pressed Steel, Messrs., 132
 Pressure or 'Oyster' mines, 162
Princess Irene, British minelayer, 51, 52
 Margaret, British minelayer, 51, 54, 60, 67, 74, 77, 79, 82, 83, 109
 Victoria, British minelayer, 114, 130, 131, 138, 145, 146
 Production of mines. *See* Supply.
 Psychology, study of enemy, 199
P.26 sunk by mine, 61
 Public declaration of mined areas, 174, 175, 176, 180
 Baltic, 1940, 145
 Dover, 1939, 123
 East Coast, 1939, 130
 Heligoland, 1917, 60
 Heligoland, 1939, 140
 Northern Barrage, 1917, 68
 North Sea, 1914, 48
 North-western Approaches, 1918, 80
 Norway, 1918, 70
 Norway, 1940, 140, 145
 Orkneys-Iceland, 1940, 133
- 'Q' MESSAGES, 107, 185
Quinnebaug, American minelayer, 68
- RAMSAY, ADMIRAL SIR BERTRAM, 161
Ramsey engages enemy minelayer, 53
 Rear-Admiral (minelayers), 67, 131, 148
Recruit sunk by mine, 61
Redstart, British controlled minelayer, 115
 Restricted life of mines, artificially, 55, 160
 Results achieved. *See* Great Britain.
 Rhine, laying of drifting mines, 188
Ringdove, British controlled minelayer, 115
Roanoke, American minelayer, 68
Rorqual, British minelaying submarine, 109, 147, 156, 162
 Royal Australian Air Force, 157
 Canadian Air Force, 157
 Canadian Navy, 147
 Engineers responsible for controlled mining, 25
 Netherlands Navy, 131, 137, 146, 156, 157, 162
 Norwegian Navy, 147
Royalist, British minelaying cruiser, 59, 60
Rubis, French minelaying submarine, 146, 157
Ruses de guerre, 139, 148, 154, 186
Russell sunk by mine, 57
Russell II, British minelaying trawler, 54, 77
 Russia, policy and development, 30, 32, 33, 35, 38, 42, 50, 86
 Russo-Japanese War, 32 et seq.
- SAFETY SWITCHES, 58, 67
Sai Yen damaged by mine, 34
 St. George's Channel minefields, 136, 137
 St. Vincent, Earl, 2, 14
Sandfly, British minelaying destroyer, 80
 Sandford, Lieutenant, oscillating mines, 37, 52
San Francisco, American minelayer, 68
Saranac, American minelayer, 68
 Satow, Sir Ernest, 179
 'Sauter-Harle' mine, 39

- Savitri*, British minelaying trawler, 77
 Scapa Flow, mine defences, 47, 50
Scharnhorst and *Gneisenau* damaged by mines, 152, 191
 Scheldt, minelaying off, 146
 'Schneider' mine, 39
 Science, contribution of, 125, 129, 193, 198
 'Scotti' mine, 41
 Sea-air power, 181, 196
Seal, British minelaying submarine, 109, 145
Sevastopol damaged by mine, 34
Shackleton, British minelaying trawler, 54
Shawmut, American minelayer, 68
Shepperton, British minelayer, 114, 123
 Shipping, instructions for safe passage, 107, 129, 174, 180
 Ship's speed when minelaying, 112
 Sicilian waters, minelaying in, 147
 Singapore mine depot, 117
 Singer's mine, 19
 Sinkers, development, 4, 58, 91
 Sinking plugs, 55, 59
 Skimming sweeps, 67, 80, 131
 'S.M.' scheme, 76
 Snag-line mines, 156
 Somerville, Admiral Sir James, 148
 Sound, the, minelaying in, 145
 South-east Asia Command, minelaying operations, 148, 151
Southern Prince, British minelayer, 132, 138
 South-west Pacific, minelaying operations, 157, 162
 Spanish-American War, 31
Speedy sunk by mine, 45
Sperrbrechers, attack on, 153, 159
 Spezia, mining of, 157
 Sprocket-wheel evader, 44
 Stadtlandet minefields, 140, 151
 Start Point, controlled minefields, 84
 Storage. *See* Supply.
Strathcoe, British minelaying trawler, 77
 Strauss, Rear-Admiral Joseph, U.S.N., 68
Stuttgart, German minelaying cruiser, 45
Stygian, British submarine, 182
 Submarine minelayers, 38, 52, 55, 82, 109, 162
 Suez Canal, minesweeping by aircraft, 129
 Sullivan, Mr. J. L., 196
 Superintendent of Mine Design, 88, 199
 Supply and storage of mines, 67, 70, 84, 115, 116, 118, 132, 157, 158
Surprise sunk by mine, 61
 Switch horns, 92
Takao attacked by midget submarine, 182
Takasago damaged by mine, 34
Tarpon, British minelaying destroyer, 59, 60, 80
 Taut wire measuring gear, 55, 140, 147
Telemachus, British minelaying destroyer, 59, 60, 80
Teviot Bank, British minelayer, 114, 131, 138, 162
 Thames Estuary minefields, 60, 84
 Tidal range, effect of, 90
 Tide compensators, 90
 Togo, Admiral, 34
Tornado sunk by mine, 61
 Torpedo Branch of the Royal Navy, 42
Torrent sunk by mine, 61
 Trawler Reserve, 36, 57
 Trincomali mine depot, 117
Tripoli, Italian minelayer, 41
 Turkey, mining policy, 40
 'Turtle' boat, 15
 20th Destroyer Flotilla, 80, 83, 140, 145, 147
 Two-speed destroyer sweep, 105
 U-boats, 46, 54, 60, 61, 78, 188, 190
 Underwater attack, ethics of, 13
 nature of development, 181, 183
 United States Naval Institute Proceedings, 15
 Navy, *Ariadne* attached to, 158
 Navy, Bureau of Naval Ordnance, 65
 Navy, tribute to, 199
 of America, policy and operations, 41, 64, 68, 156, 157
 Unorthodox systems of mining, 188
Vanoc, British minelaying destroyer, 59, 80
Vanquisher, British minelaying destroyer, 59, 80
Vehement, British minelaying destroyer, 59, 80, 83
Velox sunk by mine, 53
Venetia, British minelaying destroyer, 59
Venturous, British minelaying destroyer, 59, 80
Vernon Torpedo School, 28, 31, 35, 56, 88, 106, 181, 199
 Vestfjord minefields, 140
 Vickers, Messrs., 37, 146
 Vicksberg, mine defences, 18
Vivacious, British minelaying destroyer, 59
Wahine, British minelayer, 54, 60, 67, 83
 War of American Independence, 7 et seq.
Welbeck, British minelaying trawler, 54

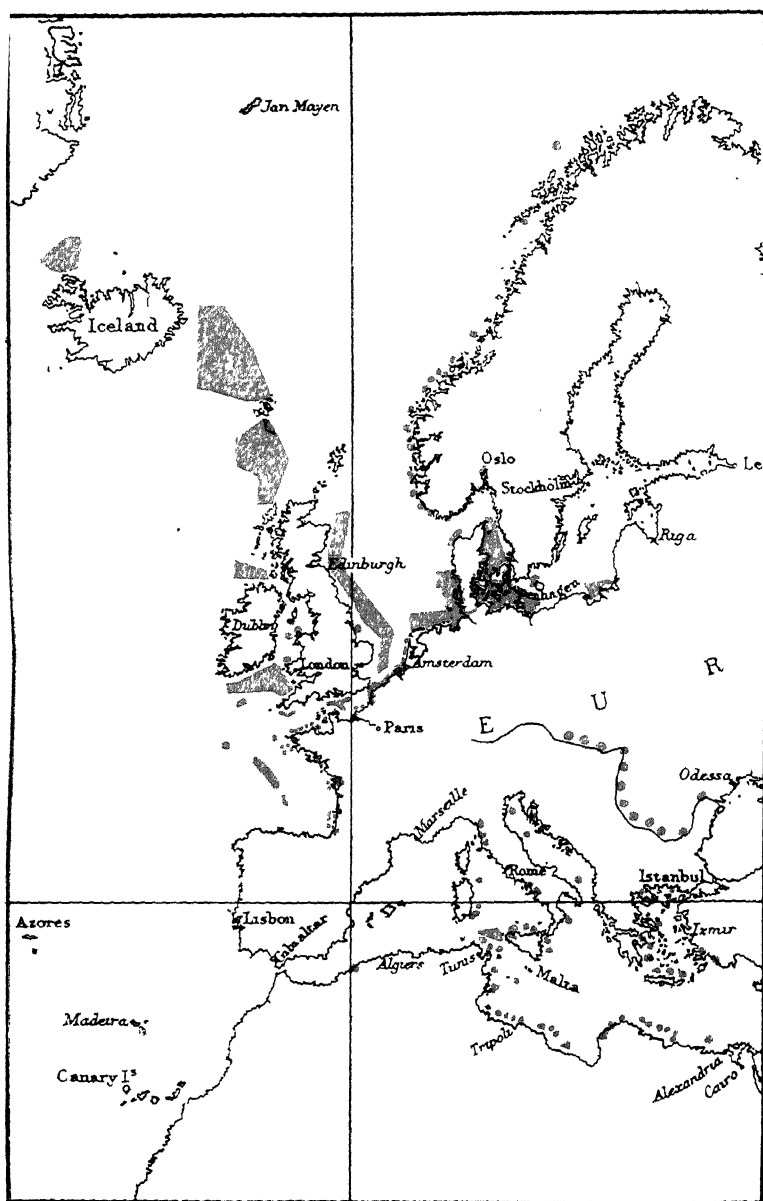
- Welshman*, British fast minelayer, 113,
 151, 152, 156
Weser River, minefields off, 145
 'Wilfrid', Operation, 144
Willem Van der Zaan, Dutch minelayer,
 131, 137
Wilson, Admiral Sir A.K., 52, 75
 Wire and bogie method of minelaying,
 110
Wolf, German raider, 61
Wolseley Motors, Messrs., 132
Wrabness, mine depot, 117
W.R.N.S., assembly of special mines, 158
X.E.3, BRITISH MIDGET SUBMARINE, 182
X.149, British minelaying lighter, 59, 61
Yashima damaged by mine, 34
Yenisei, Japanese minelayer, 35
 ZAZOO RIVER MINE DEFENCES, 18



BRITISH AND AMERICAN MINEFIELDS, 1914-18



BRITISH MINEFIELDS IN THE FAR EAST, 1939-45



BRITISH MINEFIELDS IN EUROPE, 1939-45

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